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PART 1 - PURPOSE AND SCOPE

The purpose of this manual is to set out minimum design criteria for new additions, modifications, or extensions of the 15 kV primary electrical distribution system at the Montana State University Campus, Bozeman, Montana. The primary electrical distribution system for the core campus is to be an underground system. Overhead distribution will only be considered in the outlying areas.

It is the intent of the State of Montana and MSU operating personnel that the primary electrical distribution system expand in a structured, utility oriented manner that will assure dependable electrical service to all campus facilities.

It is essential that the new primary electrical equipment and construction has functional interchangeability with existing equipment and construction.

Secondary electrical equipment and facilities are not included in this design manual.

It is expected that from time to time, new technology will become available which will update this manual. Part V is provided to allow for revisions which have been accepted and have become part of the design criteria in this design manual.

PART 2 - DESIGN CRITERIA

2.1 CIRCUIT LOADING

- A. Existing primary electrical system consists of eight (8) circuits (9A, 9B, 9C, 10A, 10B, 11A, 11B, and 11C) and two (2) express feeder circuits (12A and 12B) emanating from the Northwestern Energy Substation at 11th Avenue and College Street.
- B. Each feeder conductor is rated for 200 amps maximum continuous load current or 4320 kVA at 7.2/12.47 kV. Each express feeder conductor is rated for 370 amps maximum continuous load current or 7980 kVA at 7.2/12.47 kV. The peak load current on any feeder circuit shall be limited to 50% of rated maximum load current to allow for contingency backup feeds to other circuits.
- C. When new electrical service is required at the MSU Campus, sufficient studies shall be done to assure that the new electrical service will not cause diversified feeder circuit loading to exceed the 50% criteria outlined above.
- D. Normally open points for contingency backup feeds shall be maintained with group-operated three phase switches in switchgear or pad-mount transformers.

2.2 INTERFACE WITH EXISTING SYSTEM

- A. New feeder circuits or extensions of existing feeder circuits shall be connected to the existing system utilizing group-operated three phase switches in pad-mount switchgear or pad-mount transformers
- B. Tie circuits shall be extended, modified, or replaced as necessary to maintain contingency backup sources for all feeder circuits.
- C. Phase sequence all primary terminations prior to energizing equipment or energizing equipment from two sources. Determine the phase sequence of the existing system and insure that the phasing of the new system is the same as the existing phasing.

2.3 DUCT BANK AND CABLE SYSTEMS

- A. Duct bank shall consist of 4 inch (IN) nominal diameter for feeder and 5 IN nominal diameter for express feeder circuits, type EB conduit shall be backfilled with sand to 3 IN above the top of conduit. A 4IN thick, non-reinforced concrete slab shall be poured directly over the sand backfill. Horizontal and/or vertical conduit bends when required shall have minimum bend radius of 4 feet (FT). Sufficient spare conduits shall be installed for future expansion of the campus electrical system. A minimum of one spare conduit, of the largest conduit diameter in the duct bank, shall be provided in all new duct banks.

ELECTRICAL DESIGN STANDARDS - MONTANA STATE UNIVERSITY

- B. Manhole requirements shall be determined by evaluating cable pulling calculations and future distribution system expansion. (See Part 3.5) Manholes shall be fabricated of steel reinforced concrete. Minimum size shall be 8 FT x 6 FT x 6 IN 4 IN high, with a 36 IN diameter round cover and solid floor. Manholes shall be structurally designed for AASHTO-HS20-44 traffic loading. Manholes shall have provisions for system grounding and racking primary cables in manholes. Conduit penetrations in new and existing manholes shall utilize bell end fittings. Additional conduit entrances required in existing manhole walls shall be core drilled.
- C. Vaults shall be installed beneath all pad-mount transformers and switchgear. Base of vault shall be a minimum of 3 FT 6 IN below finish grade. Vault and pad dimensions shall be determined by size and weight of equipment. Vault shall be large enough to accommodate radius of pulling sheave determined by cable pulling calculations (Reference Part 3.5). Vaults may be concrete or fiberglass construction.
1. Due to vault installation near grounds keeping or snow removal, vaults shall be concrete unless fiberglass is reviewed and approved by MSU.
- D. Primary power cables for feeder and express feeder circuits shall be one of the three conductor sizes listed below and specified in Part III:
1. 4/0 aluminum conductor shall be used for any extension or installation of new feeder circuits. Modification of existing feeder circuits shall be evaluated to determine whether larger conduit is required to maintain feeder ampacity or if copper conductor is installed in existing conduits to maintain feeder ampacity. Feeder conductor shall be approved by MSU.
 2. 1/0 aluminum conductor is permitted for use on minor radial taps that are not part of the main loop feeder.
 3. 500 kcmil aluminum conductor shall be used for any extension or installation of new express feeder circuits. Modification of existing express feeder circuits shall be evaluated to determine whether larger conduit is required to maintain feeder ampacity or if copper conductor is installed in existing conduits to maintain feeder ampacity. Express feeder conductor shall be approved by MSU.
 - a. "T" taps on a feeder circuit are not permissible under any circumstance.

- E. Cable pulling calculations shall be performed for all new conduit/cable sections as outlined in EPRI Research Project 1519-1, EL-3333-CCM, Vol. 2 “Cable User’s Guide” or applicable Cable Manufacturer’s reference such as Anaconda publication PC-7600-1 “Cable Installation Manual.” The cable manufacturer shall be consulted for actual cable weight, maximum allowable pulling tension, maximum allowable sidewall pressure and recommended coefficient of friction for the proposed new conduit/cable system. New cables shall be installed according to manufacturer’s instructions. Pulling tension shall be monitored and recorded during the cable pulling process and compared to tension values calculated for each cable pull.

2.4 OVERHEAD DISTRIBUTION SYSTEM

- A. Overhead distribution standards are included in this design manual for new line extensions that may be necessary in the MSU Farm area.
- B. Overhead distribution lines shall meet Rural Utility Services (RUS) standards with respect to construction specifications, physical arrangement of components and materials used.
- C. Conductors shall be installed according to stringing charts provided in this manual. Pole height and placement shall be such that National Electrical Safety Code minimum ground clearance requirements are met.
- D. The minimum clearance between any energized conductor and any building, bridge or other space that may be occupied by a non-qualified electrical worker shall meet OSHA requirements (typically 10 FT).

2.5 SWITCHGEAR

- A. Pad-mount switchgear shall be utilized to provide tap points for new electric services or to provide contingency tie points to alternate feeder circuits. When tap points are not available in existing switchgear, new switchgear shall be installed.
- B. Switchgear equipment shall be pad-mounted, meeting dead front design criteria, as specified in Part III. Switches shall be three phase group-operated with a minimum load break rating of 600 amps. Switchgear installed on primary feeders shall be 600 amp dead break type. Switchgear shall be provided with a minimum of four (4) switched ways that are independently operable with a switch stick.
- C. New switchgear shall be positioned so that the switch-operating handles can be operated with an eight (8) FT switch stick.

- D. Switchgear shall have adequate room to stack 200 amp load break elbows on back of 600 amp dead break elbows.
- E. Switchgear shall use FM Global approved fluids for switchgear, unless otherwise required.
 - 1. This fluid allows for installation closer to buildings without application of additional safeguards
 - a. Typically 3 FT horizontal spacing from buildings
 - b. 5 FT vertical distance from buildings
- F. Switchgear shall be UL listed

2.6 TRANSFORMERS

- A. New three phase transformers shall be pad-mounted, loop feed, meeting dead front design criteria, as specified in Part III. Transformer core and coil shall have triplex or five legged core design. Transformer windings shall be designed and connected for grounded-wye grounded-wye operations.
- B. Transformers shall be equipped with integral, 4 position, gang-operated, load break, three-phase loop feed switches. Four position switches shall be rotary, "T" blade design with a minimum load break rating of 200 amps.
 - 1. Looped, three-phase transformers shall have 200 amp dead break terminations.
 - 2. Radially fed three-phase transformers 75 kVA or less and single-phase transformers shall be 200 amp load break terminations
- C. Transformers shall be positioned so that switch-operating handle can be activated with an eight (8) FT switch stick.
- D. Transformers shall be FM Global approved and use FM Global approved fluids, unless otherwise required. This fluid allows for the following:
 - 1. Higher operating temperatures
 - 2. Installation closer to buildings without application of additional safeguards
 - a. Typically 3 FT horizontal spacing from buildings
 - b. 5 FT vertical distance from buildings
- E. Transformer shall be UL listed

2.7 MISCELLANEOUS COMPONENTS

A. Cable Termination Equipment

1. Primary feeder cables shall be terminated in switchgear with dead break elbow terminations rated 600 amps continuous current. Completed installation shall meet dead front design criteria. Elbows shall contain integral, capacitive test points suitable for voltage sensing.
2. Primary feeder cables shall be terminated in transformers with dead break elbow terminations rated 200 amps continuous current. Completed installation shall meet dead front design criteria. Elbows shall contain integral, capacitive test points suitable for voltage sensing.
3. Cable terminations utilizing 600 amp class dead break elbows are required for terminating express circuit primary cables or connecting new feeder circuit cables to existing 600 amp switchgear bushings.
4. 200 amp load break elbows shall be utilized for transformers and taps that are not part of the main loop feeders.
5. Cable splices, when required shall be the premolded type. Minimum continuous current rating shall be equal to or greater than the cable ampacity. Cables shall be spliced only where necessary as determined by cable pulling calculations.
 - a. T-splices shall not be permitted.

B. Cable Identification System

1. New transformers and switchgear shall be provided with permanently marked station numbers stenciled on the exterior and interior of the equipment. Existing system station number sequence shall be expanded as necessary to include new express feeder circuits, feeder circuits or tap circuits. Station numbers shall contain circuit number followed by sequentially increasing location number beginning at the Northwestern Energy Substation.
2. Cables shall be identified and tagged at each end. Identification shall include: CIRCUIT (“CKT11A”); PHASE (“PhA, PhB, PhC”); and DESTINATION STATION NUMBER (“ToSTA11A-1”). Tags shall not start with the word “FROM”. Tags shall be securely attached to cable with tie wraps. Tagging system materials shall be self-laminating, similar to Frick’s Self-Laminating Cable ID Tags.

C. System Grounding

1. System grounding assemblies shall be installed at all transformers, switchgear and manhole locations.
2. Grounding assemblies shall consist of two, 10 FT copperclad ground rods driven in undisturbed soil. Ground rods shall be installed on opposite sides of the equipment from one another. A direct buried, 1/0 copper ground wire shall connect ground rods to the primary cable neutral wires, the secondary neutral, and all groundable parts of the equipment. The ground wire shall be routed so as to provide a ground plane for personnel operating the equipment.
3. A five pound magnesium sacrificial anode shall be installed for passive, cathodic protection of the ground rods. Electrical connection of the anode to the ground system shall be made at the ground bus inside the equipment enclosure.

D. Fault Indicators

1. Fault indicators shall be installed on each phase on the load side of the pad-mount transformers and switchgear; and on each phase of radial taps from pad-mount switchgear. Fault indicators shall be self-contained, direct reading and automatically resetting.

E. Metering

1. Secondary metering units shall be installed at all new transformer installations. Meters shall record total KWH and peak KW quantities. Meters shall be CT rated with the CT's located in the transformer secondary compartment, clamped to the secondary bushings. Meters for grounded wye services shall be 13 terminal, three element, Form 9S with programmable KYZ pulse output. Meter sockets shall contain ten pole test switch and circuit closing devices.

2.8 APPLICABLE STANDARDS AND SPECIFICATIONS

- A. ICEA S-94-649 EPR insulated power cables.
- B. ASTM B-8 copper conductors.
- C. ANSI F512 PVC conduit.
- D. ASTM C150, C226, C260, C39 concrete.
- E. ASTM A615 Reinforcing steel.
- F. AASHTO-HS20-44 Traffic loading.

- G. ANSI C37.74 – Pad-mount switchgear
- H. ANSI C57.12.26 – Three-phase pad-mount transformers.
- I. ANSI C57.12.25 – Single-phase pad-mount transformer.
- J. ANSI/IEEE Std. 48 – Cable terminations
- K. ANSI/IEEE Std. 386 – Separable Insulating Connectors
- L. ANSI/IEEE Std. 400.2 – Field Testing Cables
- M. ANSI/IEEE Std. 404 – Standard for cable joints.
- N. ANSI/NEMA C12.20 – Meters
- O. NFPA 70 – National Electrical Code.
- P. ANSI C2 – National Electrical Safety Code.
- Q. UL 1072
- R. RUS Bulletin 1728F-804 Specifications for Overhead Construction

PART 3 - EQUIPMENT SPECIFICATIONS

PART 3.1 - SECTION 26 05 00
ELECTRICAL: BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Basic requirements for electrical systems.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - 2. Division 01 - General Requirements.
 - 3. Section 26 05 33 - Raceways and Boxes.
- C. The intent of the specifications is to:
 - 1. Set forth requirements of performance, type of equipment desired, standards of materials and construction, tests to be made, and guarantees to be met.
 - 2. Set forth requirements of standardization, and interchangeability with existing materials and construction.

1.2 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. Aluminum Association (AA).
 - 2. American Iron and Steel Institute (AISI).
 - 3. ASTM International (ASTM):
 - a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 4. ETL Testing Laboratories (ETL).
 - 5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. C2, National Electrical Safety Code (NESC).
 - 6. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - 7. Underwriters Laboratories, Inc. (UL).
- B. Miscellaneous:
 - 1. A single manufacturer of a "product" shall be selected and utilized uniformly throughout Project even if:
 - a. More than one (1) manufacturer is listed for a given "product" in Specifications.
 - b. No manufacturer is listed.
 - 2. Equipment, electrical assemblies, related electrical wiring, instrumentation, controls, and system components shall fully comply with specific NEC requirements related to area classification.
- C. Where UL test procedures have been established for the product type, use UL or ETL approved electrical equipment and provide with the UL or ETL label.

1.3 DEFINITIONS

- A. For the purposes of providing materials and installing electrical work the following definitions shall be used.
 - 1. Outdoor area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.

2. Shop fabricated: Manufactured or assembled equipment for which a UL test procedure has not been established.

1.4 SUBMITTALS

- A. Shop Drawings:
 1. General requirements:
 - a. Provide manufacturer's technical information on products to be used, including product descriptive bulletin.
 - b. Include data sheets that include manufacturer's name and product model number.
 - 1) Clearly identify all optional accessories.
 - c. Acknowledgement that products are UL or ETL listed or are constructed utilizing UL or ETL recognized components.
 - d. Manufacturer's delivery, storage, handling and installation instructions.
 - e. Product installation details.
 - f. See individual specification sections for any additional requirements.
 2. Systems schematics and data:
 - a. Provide system schematics where required in system specifications.
 - 1) Acknowledge all system components being supplied as part of the system.
 - 2) Utilize equipment tag numbers defined in the Contract Documents for all components.
 - 3) Provide technical data for each system component showing compliance with the Contract Document requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect nameplates on electrical equipment to prevent defacing.

1.6 AREA DESIGNATIONS

- A. The following areas shall be used to determine whether the installation location is to be approved for wet or dry equipment.
 1. Outdoor and vault areas:
 - a. Wet.
 2. Indoor areas:
 - a. Dry.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, refer to specific Electrical Specification Sections and specific material paragraphs below for acceptable manufacturers.
- B. Provide all components of a similar type by one (1) manufacturer.

2.2 UL LISTING

- A. The Montana State University's electrical system is downstream of the primary meter; therefore, all equipment (i.e. cable, terminations, transformers, switchgear, arresters, etc.) utilized for this project shall be UL Listed.

2.3 MATERIALS

- A. Electrical Equipment Support Pedestals and/or Racks:
 1. Approved manufacturers:
 - a. Modular strut:
 - 1) Unistrut Building Systems.
 - 2) Eaton B-Line.
 - 3) Globe Strut.

- 4) Thomas & Betts Superstrut.
- 2. Material requirements:
 - a. Modular strut:
 - 1) Galvanized steel: ASTM A123/123M or ASTM A153/A153M.
 - 2) Stainless steel: AISI Type 316.
 - 3) PVC coated galvanized steel: ASTM A123/A123M or ASTM A153/A153M and 20 mil PVC coating.
 - 4) Aluminum: AA Type 6063-T6.
 - b. Mounting hardware:
 - 1) Galvanized steel.
 - 2) Stainless steel.
- B. Field touch-up of galvanized surfaces.
 - 1. Zinc-rich primer.
 - a. One (1) coat, 3.0 mils, ZRC by ZRC Products.

2.4 FABRICATION

- A. Design, fabricate, and assemble equipment in accordance with modern engineering and shop practices.
- B. Manufacture individual parts to standard sizes and gages so that repair parts, furnished at any time, can be installed in field.
- C. Furnish like parts of duplicate units to be interchangeable.
- D. Ensure that equipment has not been in service at any time prior to delivery, except as required by tests.
- E. Furnish equipment which requires periodic internal inspection or adjustment with access panels which will not require disassembly of guards, dismantling of piping or equipment or similar major efforts.
 - 1. Quick opening but sound, securable access ports or windows shall be provided for inspection of chains, belts, or similar items.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install equipment as shown on Drawings and in accordance with manufacturer's directions.
- B. Install and wire all equipment and perform all tests necessary to assure conformance to the Drawings and Specification Sections and ensure that equipment is ready and safe for energization.
- C. Equipment Base:
 - 1. Construct level in both directions.
- D. Install equipment in accordance with the requirements of:
 - 1. NFPA 70.
 - 2. IEEE C2.
 - 3. The manufacturer's instructions.
- E. In general, conduit routing is shown on the Drawings.
 - 1. The Contractor is responsible for routing all conduits including those shown on one-line diagrams.
 - 2. Conduit routings and stub-up locations that are shown are approximate; exact routing to be as required for equipment furnished and field conditions.
- F. When complete branch circuiting is not shown on the Drawings:

1. A home run indicating panelboard name and circuit number will be shown and the circuit number will be shown adjacent to the additional devices (e.g., light fixture and receptacles) on the same circuit.
 2. The Contractor is to furnish and install all conduit and conductors required for proper operation of the circuit.
 3. The indicated home run conduit and conductor size shall be used for the entire branch circuit.
- G. Do not use equipment that exceed dimensions or reduce clearances indicated on the Drawings or as required by the NFPA 70.
- H. Install equipment plumb, square and true with construction features and securely fastened.
- I. Install electrical equipment, including pull and junction boxes, minimum of 6 IN from process, gas, air and water piping and equipment.
- J. Install equipment so it is readily accessible for operation and maintenance, is not blocked or concealed and does not interfere with normal operation and maintenance requirements of other equipment.
- K. Avoid interference of electrical equipment operation and maintenance with structural members, building features and equipment of other trades.
1. When it is necessary to adjust the intended location of electrical equipment, unless specifically dimensioned or detailed, the Contractor may make adjustments in equipment locations in accordance with the following without obtaining the Engineer's approval:
 - a. 1 FT at grade, floor and roof level in any direction in the horizontal plane.
 - b. 1 FT for equipment other than lighting at ceiling level in any direction in the horizontal plane.
 - c. 1 FT on walls in a horizontal direction within the vertical plane.
 - d. Padmount equipment location may not be adjusted closer to building or other padmount equipment than specified.
 - e. Changes in equipment location exceeding those defined above require the Engineer's approval.
- L. Provide electrical equipment support system per the following area designations:
1. Dry areas:
 - a. Galvanized system consisting of galvanized steel channels and fittings, nuts and hardware.
 - b. Field touch-up cut ends and scratches of galvanized components with the specified primer during the installation, before rust appears.
 2. Wet areas:
 - a. Galvanized system consisting of galvanized steel channels and fittings, nuts and hardware.
 - b. Field touch-up cut ends and scratches of galvanized components with the specified primer during the installation, before rust appears.
- M. Provide all necessary anchoring devices and supports rated for the equipment load based on dimensions and weights verified from approved submittals, or as recommended by the manufacturer.
1. Do not cut, or weld to, building structural members.
 2. Do not mount safety switches or other equipment to equipment enclosures, unless enclosure mounting surface is properly braced to accept mounting of external equipment.
- N. Provide corrosion resistant spacers to maintain 1/4 IN separation between metallic equipment and/or metallic equipment supports and mounting surface in wet areas, on below grade walls and on walls of liquid containment or processing areas such as Basins, Clarifiers, Digesters, Reservoirs, etc.
- O. Do not place equipment fabricated from aluminum in direct contact with earth or concrete.

- P. Screen or seal all openings into equipment mounted outdoors to prevent the entrance of rodents and insects.
- Q. Do not use materials that may cause the walls or roof of a building to discolor or rust.

3.2 FIELD QUALITY CONTROL

- A. Verify exact rough-in location and dimensions for connection to electrified equipment, provided by others.
- B. Equipment Monitoring and Testing Plans:
 - 1. Approved in accordance with Shop Drawing submittal schedule.
 - 2. Included as a minimum:
 - a. Qualifications of firm, field personnel, and analysis personnel doing the Work.
 - b. List and description of testing and analysis equipment to be utilized.
 - c. List of all equipment to be testing, including:
 - 1) Name and tag numbers identified in the Contract Documents.
 - 2) Manufacturer's serial numbers.
 - 3) Other pertinent manufacturer identification,
- C. Replace equipment and systems found inoperative or defective and re-test.
- D. The protective coating integrity of support structures and equipment enclosures shall be maintained.
 - 1. Repair galvanized components utilizing a zinc rich paint.
 - 2. Repair painted components utilizing touch up paint provided by or approved by the manufacturer.
 - 3. Repair PVC coated components utilizing a patching compound, of the same material as the coating, provided by the manufacturer of the component.
 - 4. Repair surfaces which will be inaccessible after installation prior to installation.
 - 5. See Specification Section 26 05 33 for requirements for conduits and associated accessories.
- E. Replace nameplates damaged during installation.

3.3 WIRING CONNECTIONS AND TERMINATION

- A. Clean wires before installing lugs and connectors.
- B. Coat connection with oxidation eliminating compound for aluminum wire.
- C. Tape stripped ends of secondary conductors and associated connectors with electrical tape.
 - 1. Wrapping thickness shall be 150 percent of the conductor insulation thickness.
- D. Connections to carry full ampacity of conductors without temperature rise.
- E. Terminate spare conductors with electrical tape.

END OF SECTION

PART 3.2 - SECTION 26 05 13
MEDIUM VOLTAGE CABLE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Material and installation requirements for:
 - a. Medium voltage cable (601 V and above).
 - b. Cable terminations and splices.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - 2. Division 01 - General Requirements.
 - 3. Section 26 05 00 - Electrical: Basic Requirements.
 - 4. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. Association of Edison Illuminating Companies (AEIC).
 - a. CS8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46kV.
 - 2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 48, Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5kV Through 756kV or Extruded Insulation Rated 2.5 kV through 500 kV.
 - b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V.
 - 3. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
 - a. WC 74/S-93-639, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
 - 4. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - 5. Underwriters Laboratories, Inc. (UL):
 - a. 486A-486B, Wire Connectors.
 - b. 1072, Standard for Safety Medium Voltage Power Cables.
- B. Qualifications:
 - 1. Cable technician:
 - a. Three (3) years experience in handling, terminating and splicing medium voltage cables.
 - b. Specifically trained by a factory representative on the terminations and splices to be used on the project.
 - 1) If not trained on the products to be used, on-site training by the factory representative shall be performed before any terminations or splices are made.

1.3 SUBMITTALS

- A. Shop Drawings:
 - 1. Product data:

- a. Provide submittal data for all products specified in PART 2 of this Specification Section.
 - b. See Specification Section 26 05 00 for additional requirements.
- 2. Fabrication and/or layout drawings:
 - a. Cable pulling plan.
- 3. Factory Tests:
 - a. Conductor resistance testing
 - b. Insulation resistance testing
 - 1) Shall be measured in megohms/100 feet
 - 2) Shall not be less than 50,000 megohms/1000 feet when corrected to 60 degC.
 - c. Concentric neutral resistance
- B. Informational Submittals:
 - 1. Cable pulling tension measurements.
 - 2. Submit the following before terminating cables:
 - a. Cable Technician qualifications.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Ship cable with removable watertight end seals, and store in dry place.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Wire and cable:
 - a. The Okonite Company.
 - b. General Cable.
 - c. The Kerite Company.
 - d. Prysmian Cable Corporation.
 - e. Southwire Company.
 - 2. Lugs, connectors and terminations:
 - a. Eaton Cooper Power Systems.
 - b. 3M Company.
 - c. Elastimold, a Thomas and Betts Company.
 - d. Hubbell
 - e. Joslyn.
 - f. Raychem.

2.2 MEDIUM VOLTAGE CABLES

- A. General:
 - 1. Cable shall be suitable for use in wet and dry locations in conduit, underground duct, direct burial and aerial riser installations.
- B. Shipping Lengths:
 - 1. Contractor shall determine required quantity of cable.
 - 2. Cable shipping lengths shall be determined such that cable splices are not required except at those locations determined necessary by cable pulling calculations.
 - 3. Additional cable splices, for any reason, will not be acceptable and will be cause for rejection.
- C. Ratings:
 - 1. 15kV class unless otherwise indicated on the Drawings.
- D. Standards:
 - 1. NEMA/ICEA WC 74/S-93-639.

2. AEIC CS8.
 3. UL 1072.
- E. Conductor configuration:
1. Single conductors, Triplex configuration in conduit
- F. Conductor Material - new:
1. Compact stranded aluminum.
 2. Class B strand
- G. Conductor Material – Replace in kind:
1. Compact stranded copper.
 2. Class B strand
- H. Insulation:
1. Temperature rating: Type MV-90 or MV-105 per NFPA 70.
 2. Ethylene-propylene rubber (EPR) base
 3. 133 percent insulation level (220 mil).
- I. Shielding:
1. Shielding on cables rated above 2 kV consists of:
 - a. Semiconductor conductor screen.
 - 1) Resistivity not in excess of 50,000 ohm-cm at 90 degC
 - 2) Average thickness of 15 mils
 - 3) Free stripping from conductor and firmly bonded to insulation.
 - b. Semiconductor insulation screen.
 - 1) Resistivity not in excess of 50,000 ohm-cm at 90 degC
 - 2) Free stripping from conductor and firmly bonded to insulation.
 - c. 1/3 Copper concentric neutral.
- J. Jackets:
1. Direct buried cables shall be rated for direct bury.
 2. Jacket:
 - a. PVC or Polyethylene.
 - b. Jacket shall be installed in such a manner that neutral wires are not displaced and voids between neutral wires and the jacket are negligible.
 - c. Print manufacturer's name, cable type, insulation thickness, conductor size and type, rated voltage, sequential footage number, and year of manufacture on the jacket in contrasting ink.
- K. Conduit Fill:
1. New conduit for MV cable to be Schedule 40 PVC conduit, unless otherwise shown on Drawings
 - a. 1/0 and 4/0 conductor shall utilize 4-inch or larger
 - b. 500 aluminum and 350 copper conductor shall utilize 5-inch or larger
 2. MV cable to be installed meet NEC conduit fill requirements:
 - a. Single Cable – 53 percent filled
 - b. Three or more conductors – 40 percent filled
- L. Installation Schedule:
1. New express feeder circuits to be 500 kcmil aluminum
 2. Replacement express feeder circuits to be 350 kcmil copper, unless approved by Owner
 3. New feeder circuits to be 4/0 aluminum
 4. Replacement feeder circuits to be 4/0 copper, unless approved by Owner
 5. Minor taps to be 1/0 aluminum
- M. Operating temperature:
1. 90 degrees C for normal operation
 2. 130 degrees C for emergency operation

3. 250 degrees C for short circuit condition

2.3 CABLE ACCESSORIES

A. Lugs and Connectors:

1. Lugs:
 - a. Compression type.
 - b. Standard: UL 486A for copper cables.
 - c. Voltage rating: Up to 35 kV.
 - d. Current rating: Continuous operation at the rating of the cable.
 - e. Material: Tin-plated copper.
 - f. Number of holes: Two (2), except one (1) on motor leads.
2. Splice connectors:
 - a. Standard: UL 486A for copper cables.
 - b. Voltage rating: Up to 35kV.
 - c. Current rating: Continuous operation at the rating of the cable.
 - d. Material: Tin-plated copper

B. Terminations:

1. General:
 - a. All components shall be premolded and factory tested
 - b. All components shall be deadfront design
2. Nominal voltage:
 - a. 15 kV
 - b. 95 kV BIL
 - c. 60 Hz
3. Operating voltage:
 - a. 7.2/12.5 kV grounded wye
4. Capable of switching on a three-phase system.
5. End caps:
 - a. Cold or hot shrink.
 - b. Used to environmentally seal and mechanically protect exposed cable ends.
6. Cold shrink kits:
 - a. Standard: IEEE 48, Class 1 termination.
 - b. Voltage rating: Same as the cable rating.
 - c. Current rating: Continuous operation at the rating of the cable.
 - d. One-piece design, where high-dielectric constant stress control is integrated within a skirted insulator made of silicone rubber.
 - e. Suitable for contaminated indoor and outdoor locations.
7. Molded rubber kit:
 - a. Standard: IEEE 48.
 - b. Voltage rating: Same as the cable rating.
 - c. Current rating: Continuous operation at the rating of the cable.
 - d. One-piece design or modular with stress cone and skirts, where high-dielectric constant stress control is integrated within a skirted insulator made of EPDM rubber.
 - e. Suitable for contaminated indoor and outdoor locations.
8. Elbow connectors:
 - a. Standard: IEEE 386.
 - b. Voltage rating: Same as the cable rating.
 - c. Current rating: See Drawings for installation location.
 - d. One-piece design, comprised of an insulation shield, insulation layer and an outer shield constructed of EPDM rubber.
 - e. 200 amp installations:
 - 1) Deadfront, loadbreak type with:
 - a) Hot stick pulling eye.
 - b) Grounding tab.

- c) Test point.
 - d) Continuous current rating: 200 amps
- f. 600 amp installations:
 - 1) Deadfront, deadbreak type with:
 - a) T-body type.
 - b) Grounding tab.
 - c) Test point.
 - d) Continuous current rating: 600 amps
- g. Accessories to be constructed in a similar manner as the elbow connector:
 - 1) Bushing inserts.
 - 2) Bushing well plugs.
 - 3) Feed thru inserts.
 - 4) Protective caps.

C. Splices:

- 1. Cold shrink kits:
 - a. Standard: IEEE 404.
 - b. Voltage rating: Same as the cable rating.
 - c. Current rating: Continuous operation at the rating of the cable.
 - d. One-piece design, comprised of an insulation shield, insulation layer and a silicone rubber body.
 - e. Suitable for indoor, direct burial or submersible applications.
- 2. Molded rubber kit:
 - a. Standard: IEEE 386 or IEEE 404.
 - b. Voltage rating: Same as the cable rating.
 - c. Current rating: Continuous operation at the rating of the cable.
 - d. One- or multi-piece design, comprised of an insulation shield, insulation layer and an outer shield constructed of EPDM rubber.
 - e. Suitable for indoor, direct burial or submersible applications.
- 3. Modular separable molded rubber:
 - a. Standard: IEEE 386.
 - b. Voltage rating: Same as the cable rating.
 - c. Current rating: 600A.
 - d. One-piece design, comprised of an insulation shield, insulation layer and an outer shield constructed of EPDM rubber.
 - e. Deadfront, deadbreak type.
 - f. Components: T-body, insulating plug with cap, insulating plug with cap and stud, and connecting plug.
 - g. Suitable for submersible applications.

D. Elbow Arrester

- 1. Approved manufacturer
 - a. Eaton Cooper
 - b. Or approved equal
- 2. Requirements
 - a. 15 kV
 - b. Load break elbow
 - c. #4 copper ground or larger
 - d. 1 elbow per phase
 - e. 8.4 MCOV

E. Parking Stand Arrester

- 1. Approved manufacturer
 - a. Eaton Cooper
 - b. Or approved equal
- 2. Requirements

- a. 15 kV
 - b. Load break elbow
 - c. #4 copper ground or larger
 - d. 1 arrester per phase
 - e. 8.4 MCOV
- F. Fault Indicators
 - 1. Type 1
 - a. Test Point Reset
 - b. 300A Trip
 - 2. Type 2
 - a. Current Reset
 - b. 300A Trip
- G. Cable Shield Grounding Adapters:
 - 1. Type: Molded rubber with constant force spring and solder-blocked tinned copper braid pigtail.
 - 2. Waterproof, providing a positive seal for the cable jacket.
 - 3. May be integral with termination of splice device with Engineer's approval.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Do not install cable during wet conditions.
 - 1. Prior to pulling cables, drain or pump out manholes and other low points if standing water is present.
 - 2. Blow out conduits with dried compressed air if moisture is present in conduits.
 - 3. Install end caps immediately on all cut ends of cable prior to pulling, and maintain end caps while pulling in cable.
 - a. If end caps are damaged, remove and install new end caps.
 - b. Do not remove end caps until ready to terminate or splice cable.
- B. Cable Installation in Manholes:
 - 1. Provide enough cable slack in each manhole for a complete loop around the manhole.
 - a. When cable is spliced in a manhole, provide enough cable slack for a complete loop around the manhole.
 - b. The loop will provide slack to facilitate future cable repairs.
 - 2. Arc-proof all cables in manholes.
 - a. Apply in spiral, half-overlap fashion to full exposed length of each cable in manhole.
 - b. Secure in place with glass cloth electrical tape.
 - 1) Apply in reverse spiral to arc-proofing tape, at maximum interval of 9 IN and double wrapped at each end.
- C. Do not install conductors when ambient temperature is near minimum as recommended by manufacturer for installation of the type of conductor insulation.
- D. Provide components in kit form, complete with instructions, supplied by a single approved manufacturer and suitable for each shielded cable termination.
 - 1. Select correct termination to match cable diameter and construction.
 - 2. Form and install terminations in strict accordance with instructions of cable manufacturer and termination manufacturer.
- E. Splices:
 - 1. Provide components in kit form, complete with instructions, supplied by a single approved manufacturer and suitable for the type of cable being used.
 - 2. Prepare cable ends, provide materials and follow all application steps in accordance with manufacturer's instructions.

- a. As a minimum requirement:
 - 1) The cable ends shall be cut squarely.
 - 2) The insulation shall be free from nicks or burrs after removal of jacket.
 - 3) The conductors shall be cleaned and an oxide inhibitor applied.
 - 4) For splices, connector indents shall be filled with insulating putty to eliminate voids or prepared per manufacture's instructions.
 - 5) Attach grounding lead to system ground.
- 3. Splices shall be avoided whenever possible.
 - a. No more than one (1) splice is permitted between termination points without Engineer's approval.
 - b. No splices are permitted in runs less than 100 FT long.
 - c. Splices will be made only at manholes or other accessible locations.
 - d. Do not pull splices into duct banks or conduits or leave them under tension.
- F. The ground shield grounding adaptors shall be grounded:
 - 1. Shired and elbow terminators: Grounded to ground bar or cable loop in equipment.
 - 2. Splices: Grounded to ground bar or rod in manhole.
 - 3. Connect with insulated, stranded #6 AWG wire.

3.2 FIELD QUALITY CONTROL

- A. Provide cable pulling plan showing all proposed splice points and cable pulling direction for each pull.
- B. Provide measurement of tensions during the pull.
- C. See Specification Section 26 08 13 for acceptance testing requirements.

END OF SECTION

PART 3.3 - SECTION 26 05 26

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Material and installation requirements for grounding and bonding system(s).
 - 2. Grounding assemblies shall be installed at all transformers, switchgear, and manhole locations.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - 2. Division 01 - General Requirements.
 - 3. Section 26 05 00 - Electrical: Basic Requirements.
 - 4. Section 26 05 13 - MV Cable.
 - 5. Section 26 05 33 - Raceways and Boxes.
 - 6. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. ASTM International (ASTM):
 - a. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 837, Standard for Qualifying Permanent Connections Used in Substation Grounding.
 - 3. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - 4. Underwriters Laboratories, Inc. (UL):
 - a. 467, Grounding and Bonding Equipment.
- B. Assure ground continuity is continuous throughout the entire Project.

1.3 SUBMITTALS

- A. Shop Drawings:
 - 1. Product technical data.
 - a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
 - 1) Grounding clamps, terminals and connectors.
 - 2) Exothermic welding system.
 - b. See Specification Section 26 05 00 for additional requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Ground rods and bars and grounding clamps, connectors and terminals:
 - a. Erico Products, Inc.
 - b. Harger Lightning & Grounding.
 - c. Heary Brothers.
 - d. Hubbell - Burndy.
 - e. Robbins Lightning Protection.

- f. Thomas & Betts - Blackburn.
- g. Thompson Lightning Protection.
- 2. Exothermic weld connections:
 - a. Erico Products Inc., Cadweld.
 - b. Harger Lightning & Grounding - Ultraweld.
 - c. Hubbell - Burndy (Thermoweld).
 - d. Thomas & Betts - Furseweld.

2.2 COMPONENTS

- A. Wire and Cable:
 - 1. Bare conductors: Soft drawn stranded copper meeting ASTM B8.
- B. Conduit: As specified in Specification Section 26 05 33.
- C. Ground Bars:
 - 1. Solid copper:
 - a. 1/4 IN thick.
 - b. 2 or 4 IN wide.
 - c. 24 IN long minimum in main service entrance electrical rooms, 12 IN long elsewhere.
 - 2. Predrilled grounding lug mounting holes.
 - 3. Stainless steel or galvanized steel mounting brackets.
 - 4. Insulated standoffs.
- D. Ground Rods:
 - 1. 3/4 IN x 10 FT.
 - 2. Copper-clad:
 - a. 10 mil minimum uniform coating of electrolytic copper molecularly bonded to a rigid steel core.
 - b. Corrosion resistant bond between the copper and steel.
 - c. Hard drawn for a scar-resistant surface.
- E. Grounding Clamps, Connectors and Terminals:
 - 1. Mechanical type:
 - a. Standards: UL 467.
 - b. High copper alloy content.
 - 2. Compression type for interior locations:
 - a. Standards: UL 467.
 - b. High copper alloy content.
 - c. Non-reversible.
 - d. Terminals for connection to bus bars shall have two bolt holes.
 - 3. Compression type suitable for direct burial in earth or concrete:
 - a. Standards: UL 467, IEEE 837.
 - b. High copper alloy content.
 - c. Non-reversible.
 - d. Factory filled with oxide inhibiting compound.
- F. Exothermic Weld Connections:
 - 1. Copper oxide reduction by aluminum process.
 - 2. Molds properly sized for each application.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General:
 - 1. Install products in accordance with manufacturer's instructions.
 - 2. Size grounding conductors and bonding jumpers in accordance with NFPA 70, Article 250, except where larger sizes are indicated on the Drawings.

3. Remove paint, rust, or other non-conducting material from contact surfaces before making ground connections.
 4. Do not splice grounding conductors except at ground rods.
 5. Install ground rods vertically and grounding conductors in undisturbed, firm soil.
 - a. Provide excavation required for installation of ground rods and ground conductors.
 - b. Use driving studs or other suitable means to prevent damage to threaded ends of sectional rods.
 - c. Unless otherwise specified, connect conductors to ground rods with compressor type connectors or exothermic weld.
 - d. Provide sufficient slack in grounding conductor to prevent conductor breakage during backfill or due to ground movement.
 - e. Backfill excavation completely, thoroughly tamping to provide good contact between backfill materials and ground rods and conductors.
 6. Do not use exothermic welding if it will damage the structure the grounding conductor is being welded to.
- B. Grounding Electrode System:
1. Provide a grounding electrode system in accordance with NFPA 70, Article 250 and as indicated on the Drawings.
 2. Grounding conductor terminations:
 - a. Ground bars mounted on wall, use compression type terminal and bolt it to the ground bar with two bolts.
 - b. Ground bars in electrical equipment, use compression type terminal and bolt it to the ground bar.
 - c. Piping systems use mechanical type connections.
 - d. Building steel, below grade and encased in concrete, use compression type connector or exothermic weld.
 3. Ground ring grounding system:
 - a. Ground ring consists of ground rods and a grounding conductor looped around the structure.
 - b. Placed at a minimum of 10 FT from the structure foundation and 2 FT-6 IN below grade.
 - c. Provide a minimum of four (4) ground rods placed at the corners of the structure and additional rods so that the maximum distance between ground rods does not exceed 50 FT.
 - d. Building/Structure grounding:
 - 1) Bond building/structure metal support columns to the ground ring at all corners of the structure.
 - e. Grounding conductor: Bare conductor, 1/0 copper ground wire, unless larger is indicated on Drawings.
 - f. Grounding conductor shall connect the ground rods, primary cable neutral wires, secondary neutral, and all groundable parts of the equipment.
- C. Raceway Bonding/Grounding:
1. All metallic conduit shall be installed so that it is electrically continuous.
 2. All conduits to contain a grounding conductor with insulation identical to the phase conductors, unless otherwise indicated on the Drawings.
 3. NFPA 70 required grounding bushings shall be of the insulating type.
 4. Provide double locknuts at all panels.
 5. Bond all conduit, at entrance and exit of equipment, to the equipment ground bus or lug.
 6. Provide bonding jumpers if conduits are installed in concentric knockouts.
 7. Make all metallic raceway fittings and grounding clamps tight to ensure equipment grounding system will operate continuously at ground potential to provide low impedance current path for proper operation of overcurrent devices during possible ground fault conditions.

- D. Equipment Grounding:
 - 1. All utilization equipment shall be grounded with an equipment ground conductor.
- E. Manhole Grounding:
 - 1. Provide a ground rod and ground bar, when indicated or as needed, in each manhole and handhole with exposed metal parts.
 - a. Expose a minimum of 4 IN of the rod above the floor for field connections to the rod.
 - 2. Connect all exposed metal parts (e.g., conduits and cable racks) to the ground rod.

3.2 FIELD QUALITY CONTROL

- A. Leave grounding system uncovered until observed by Owner.
- B. Acceptance testing:
 - 1. See Specification Section 26 08 13.

END OF SECTION

PART 3.4 - SECTION 26 05 43
ELECTRICAL: EXTERIOR UNDERGROUND

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Material and installation requirements for:
 - a. Vaults.
 - b. Underground conduits and ductbanks.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.
 - 3. Section 26 05 26 - Grounding.

1.2 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. HB, Standard Specifications for Highway Bridges.
 - 2. American Iron and Steel Institute (AISI).
 - 3. ASTM International (ASTM):
 - a. A536, Standard Specification for Ductile Iron Castings.
 - b. D2564, Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
 - c. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 - d. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - e. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - 4. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - 5. Society of Cable Telecommunications Engineers (SCTE):
 - a. 77, Specification for Underground Enclosure Integrity.
 - 6. Underwriters Laboratories, Inc. (UL):
 - a. 467, Grounding and Bonding Equipment.
 - b. 651, Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings.

1.3 DEFINITIONS

- A. Direct-buried conduit(s):
 - 1. Individual (single) underground conduit.
 - 2. Multiple underground conduits, arranged in one or more planes, in a common trench.

1.4 SUBMITTALS

- A. Shop Drawings:
 - 1. Product technical data:
 - a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
 - 1) Conduit fittings.
 - 2) Support systems.
 - b. See Specification Section 26 05 00 for additional requirements.
 - 2. Fabrication and/or layout drawings:

- a. Provide dimensional drawings of each vault indicating all specified accessories and conduit entry locations.

1.5 SITE CONDITIONS

- A. Avoid overloading or surcharge a sufficient distance back from edge of excavation to prevent slides or caving.
 - 1. Maintain and trim excavated materials in such manner to be as little inconvenience as possible to public and adjoining property owners.
- B. Provide full access to public and private premises and fire hydrants, at street crossings, sidewalks and other points as designated by Owner to prevent serious interruption of travel.
- C. Protect and maintain bench marks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of Owner and controlling agency.
- D. Verify location of existing underground utilities.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Precast vaults:
 - a. Utility Vault Co.
 - b. Oldcastle Precast, Inc.
 - c. Lister Industries.
 - 2. Vault and ductbank accessories:
 - a. Neenah.
 - b. Unistrut.
 - c. Condux International, Inc.
 - d. Underground Devices, Inc.
 - 3. Rigid nonmetallic conduit:
 - a. Prime Conduit (Carlon).
 - b. Cantex.
 - c. Osburn Associates.
 - 4. Conduit fittings and accessories:
 - a. Appleton Electric Co.
 - b. Carlon.
 - c. Cantex.
 - d. Crouse-Hinds.
 - e. Killark.
 - f. Osburn Associates.
 - g. OZ Gedney Company.
 - h. RACO.
 - i. Steel City.
 - j. Thomas & Betts.
 - 5. Support systems:
 - a. Unistrut Building Systems.
 - b. Eaton B-Line.
 - c. Kindorf.
 - d. Minerallac Fastening Systems.
 - e. Caddy.
 - f. Thomas & Betts Superstrut.

2.2 VAULTS

- A. Precast vaults:
 - 1. Fiberglass reinforced polymer concrete or steel reinforced cement concrete structures.
 - 2. AASHTO live load rating: HS-20 for full deliberate vehicle traffic.
 - 3. Minimum size: 8 FT x 6 FT x 6 FT-4 IN high
 - 4. Mating edges: Tongue and groove type.
 - 5. Solid bottom with a 12 IN x 12 IN or 12 IN DIA french drain in the bottom of each vault.
 - 6. Cover extension rings as required.
 - 7. Cable pulling eyes opposite all conduit entrances.
 - a. Coordinate exact location with installation contractor.

2.3 CONCRETE VAULT ACCESSORIES

- A. Cable Racks and Hooks:
 - 1. Material: Heavy-duty nonmetallic (glass reinforced nylon).
 - 2. Hook loading capacity: 400 LBS minimum.
 - 3. Rack loading capacity: Four (4) hooks maximum.
 - 4. Hook deflection: 1/4 IN maximum.
 - 5. Hooks: Length, as required, with positive locking device to prevent upward movement.
 - 6. Mounding hardware: Stainless steel.
- B. Cover:
 - 1. 36 IN diameter, round
- C. Conduit penetrations:
 - 1. Bell end fittings.
 - 2. Penetrations into existing vault walls shall be core drilled.
- D. Cable Pulling Irons:
 - 1. 7/8 IN DIA hot-dipped galvanized steel.
 - 2. 5000 LB minimum pulling load.
- E. Ground Rods and Grounding Equipment: See Specification Section 26 05 26.

2.4 RIGID NONMETALLIC CONDUIT

- A. Schedules 40 (PVC-40) and 80 (PVC-80):
 - 1. Polyvinyl-chloride (PVC) plastic compound which includes inert modifiers to improve UV degradation, weatherability and heat distribution.
 - 2. Rated for direct sunlight exposure.
 - 3. Fire retardant and low smoke emission.
 - 4. Shall be suitable for use with 90 DegC wire and shall be marked "maximum 90 DegC".
 - 5. Standards: UL 651.
 - 6. Size: See Section 26 05 13 for conductor requirements.
 - 7. Quantity:
 - a. A minimum of one spare conduit, matching the maximum conduit size in the duct bank, shall be installed in all new duct banks.

2.5 CONDUIT FITTINGS AND ACCESSORIES

- A. Fittings for Use with Rigid Nonmetallic PVC Conduit:
 - 1. Coupling, adapters and conduit bodies:
 - a. Same material, thickness, and construction as the conduits with which they are used.
 - b. Homogeneous plastic free from visible cracks, holes or foreign inclusions.
 - c. Bore smooth and free of blisters, nicks or other imperfections which could damage the conductor.
 - 2. Solvent cement for welding fittings shall be supplied by the same manufacturer as the conduit and fittings.
 - 3. Standards: ASTM D2564, UL 651, UL 514B.

- B. Weather and Corrosion Protection Tape:
 - 1. PVC based tape, 10 mils thick.
 - 2. Protection against moisture, acids, alkalis, salts and sewage and suitable for direct bury.
 - 3. Used with appropriate pipe primer.

2.6 CONDUIT SUPPORT SYSTEMS

- A. Multi-conduit Surface or Trapeze Type Support and Pull or Junction Box Supports:
 - 1. Material requirements:
 - a. Galvanized steel: ASTM A123/A123M or ASTM A153/A153M.
 - b. Stainless steel: AISI Type 316.
 - c. PVC coat galvanized steel: ASTM A123/A123M or ASTM A153/A153M and 20 mil PVC coating.
- B. Single Conduit and Outlet Box Support Fasteners:
 - 1. Material requirements:
 - a. Zinc plated steel.
 - b. Stainless steel.
 - c. Malleable iron.
 - d. PVC coat malleable iron or steel: 20 mil PVC coating.
 - e. Steel protected with zinc phosphate and oil finish.
- C. Duct Spacers/Supports:
 - 1. High density polyethylene or high impact polystyrene.
 - 2. Interlocking.
 - 3. Provide 2 IN minimum spacing between conduits.
 - 4. Accessories, as required:
 - a. Hold down bars.
 - b. Ductbank strapping.

2.7 FILL MATERIALS

- A. Backfill Material:
 - 1. As approved by Engineer.
 - a. Free of rock cobbles, roots, sod or other organic matter, and frozen material.
 - b. Moisture content at time of placement: 3 percent plus/minus of optimum moisture content as specified in accordance with ASTM D698.
 - 2. For conduit
 - a. Backfill within 6 inches of the conduit shall not have solid material greater than 4 inches in size, or with sharp edges likely to damage the conduit.
 - b. The remainder of backfill should be free from solid material greater than 8 inches in size.
- B. Flowable fill/concrete:
 - 1. Description: Flowable fill/concrete shall be a mixture of cement, fly ash, fine sand, water, and air having a consistency which will flow under a very low head.
 - 2. Material characteristics:
 - a. The approximate quantities of each component per cubic yard of mixed material shall be as follows:
 - 1) Cement (Type I or II): 50 LBS.
 - 2) Fly ash: 200 LBS.
 - 3) Fine sand: 2,700 LBS.
 - 4) Water: 420 LBS.
 - 5) Air content: 10 percent.
 - b. Actual quantities shall be adjusted to provide a yield of 1 cubic yard with the materials used.
 - c. Approximate compressive strength should be 85 to 175 psi.

- d. Fine sand shall be an evenly graded material having not less than 95 percent passing the No. 4 sieve and not more than 5 percent passing the No. 200 sieve.
- 3. Thickness:
 - a. Minimum 4" slab thickness over the conduits.

PART 3 - EXECUTION

3.1 GENERAL

- A. Drawings indicate the intended location of vaults and routing of ductbanks and direct buried conduit.
 - 1. Field conditions may affect actual routing.
- B. Remove and dispose of unsuitable materials as directed by Geotechnical Engineer to site provided by Contractor.
- C. Vault Locations:
 - 1. Approximately where shown on the Drawings.
 - 2. As required for pulling distances.
 - 3. As required to keep pulling tensions under allowable cable tensions.
 - 4. As required for number of bends in ductbank routing.
 - 5. Shall not be installed in a swale or ditch.
 - 6. Determine the exact locations after careful consideration has been given to the location of other utilities, grading, and paving.
 - 7. Locations are to be approved by the Engineer prior to excavation and placement or construction of vaults.
- D. Install products in accordance with manufacturer's instructions.

3.2 EXCAVATION

- A. Excavation for Appurtenances:
 - 1. 12 IN (minimum) clear distance between outer surface and embankment.
- B. Trench Excavation:
 - 1. Excavate trenches by open cut method to depth shown on Drawings and necessary to accommodate work.
 - a. Support existing utility lines and yard piping where proposed work crosses at a lower elevation.
 - 1) Stabilize excavation to prevent undermining of existing utility.
 - 2. Open trench outside buildings, units, and structures:
 - a. No more than the distance between two vaults, structures, units, or 300 LF, whichever is less.
 - b. Field adjust limitations as weather conditions dictate.
 - 3. Trench shall be backfilled immediately following installation of conduit.
 - 4. Observe following trenching criteria:
 - a. Trench size:
 - 1) Excavate width to accommodate free working space.
 - 2) Maximum trench width at top of pipe or conduit may not exceed outside diameter of utility service by more than the following dimensions:

OVERALL DIAMETER OF UTILITY SERVICE	EXCESS DIMENSION
33 IN and less	18 IN
more than 33 IN	24 IN

- 3) Cut trench walls vertically from bottom of trench to 1 FT above top of pipe, conduit, or utility service.
 - 4) Keep trenches free of surface water runoff.
 - a) Include cost in Bid.
 - b) No separate payment for surface water runoff pumping will be made.
- C. Trenching for Electrical Installations:
1. Observe the preceding Trench Excavation paragraph in PART 3 of this Specification Section.
 2. Modify for electrical installations as follows:
 - a. For trenches 12 IN to 30 IN wide, open no more than 600 LF of trench.
 - b. For trenches less than 12 IN wide, any length of trench may be opened in exterior locations.
 - c. Do not over excavate trench vertically.
 - d. Cut trenches for electrical runs with minimum 36 IN cover, unless otherwise specified or shown on Drawings.
 3. The bottom of the trench should be undisturbed, tamped, or relatively smooth earth. Where the excavation is in rock, the bottom of the the conduit should be laid on a protective layer of clean well-tamped backfill. The backfill should be adequately compacted.
- D. Flowable Fill/concrete:
1. Flowable fill/concrete shall be:
 - a. Discharged from a mixer by any means acceptable to the Engineer into the area to be filled.
 - b. Placed in 4 FT maximum lifts to the elevations indicated.
 - 1) Allow 12 HR set-up time before placing next lift or as approved by the Engineer.
 - 2) Contractor shall place flowable fill lifts in such a manner as to prevent flotation of the pipe.
 2. Flowable fill shall not be placed on frozen ground.
 3. Subgrade on which flowable fill is placed shall be free of disturbed or softened material and water.
 4. Flowable fill batching, mixing, and placing may be started if weather conditions are favorable, and the air temperature is 34 DegF and rising.
 5. At the time of placement, flowable fill must have a temperature of at least 40 DegF.
 6. Mixing and placing shall stop when the air temperature is 38 DegF or less and falling.
 7. Each filling stage shall be as continuous an operation as is practicable.
 8. Contractor shall prevent traffic contact with flowable fill for at least 24 HRS after placement or until flowable fill is hard enough to prevent rutting by construction equipment.
 9. Flowable fill shall not be placed until water has been controlled or groundwater level has been lowered.

3.3 BACKFILLING METHODS

- A. Common Trench Backfill:
1. Perform in accordance with the following:
 - a. Place backfill in lift thicknesses capable of being compacted to densities specified.
 - b. Observe specific manufacturer's recommendations regarding backfilling and compaction.
 - c. Avoid displacing joints and appurtenances or causing any horizontal or vertical misalignment, separation, or distortion.
- B. Water flushing for consolidation is not permitted.

3.4 COMPACTION

- A. General:
1. Place and assure bedding, backfill, and fill materials achieve an equal or higher degree of compaction than undisturbed materials adjacent to the work.

2. In no case shall degree of compaction below minimum compactions specified be accepted.

B. Compaction Requirements:

1. Unless noted otherwise on Drawings or more stringently by other Specification Sections, comply with following minimum trench compaction criteria.
 - a. Disturbed soil beneath equipment:

LOCATION	SOIL TYPE	COMPACTION DENSITY
All locations	Cohesionless soils	90 percent of maximum dry density by ASTM D698

- b. Bedding material:

LOCATION	SOIL TYPE	COMPACTION DENSITY
All locations	Cohesionless soils	75 percent relative density by ASTM D4253 and ASTM D4254

- c. Common trench backfill:

LOCATION	SOIL TYPE	COMPACTION DENSITY
All locations	Cohesive soils	95 percent of maximum dry density by ASTM D698

3.5 FIELD QUALITY CONTROL

A. Testing:

1. Perform in-place moisture-density tests as directed by the Owner.
2. Perform tests through recognized testing laboratory approved by Owner.
3. Costs of "Passing" tests paid by Owner.
4. Perform additional tests as directed until compaction meets or exceeds requirements.
5. Cost associated with "Failing" tests shall be paid by Contractor.
6. Assure Owner has immediate access for testing of all soils related work.
7. Ensure excavations are safe for testing personnel.

3.6 VAULTS

A. Precast vaults:

1. For use in vehicular and non-vehicular traffic areas.
2. Construction:
 - a. Grout or seal all joints, per manufacturer's instructions.
 - b. Support cables on walls by cable racks:
 - 1) Provide a minimum of two (2) racks, install symmetrically on each wall of vaults and handholes.
 - a) Provide additional cable racks, as required, so that both ends of cable splices will be supported horizontally.
 - 2) Equip cable racks with adjustable hooks: Quantity of cable hooks as required by the number of conductors to be supported.
 - c. In each vault, drive 3/4 IN x 10 FT long copper clad ground rod into the earth with approximately 6 IN exposed above finished floor.
 - 1) Drill opening in floor for ground rod.
 - 2) Connect all metallic components to ground rod by means of #8 AWG minimum copper wire and approved grounding clamps.

- 3) Utilize a ground bar in the vault or handhole if the quantity of ground wires exceeds three (3).
 - a) Connect ground bar to ground rod with a #1/0 AWG minimum copper wire.
3. Place vault on a foundation.
 - a. Foundation shall have 1/4 to 1/2 IN crushed rock or gravel.
 - b. A minimum of 8 IN thick and 6 IN larger than vaults footprint on all sides.
4. Install so that the top of cover is 1 IN above finished grade.
 - a. Where existing grades are higher than finished grades, install sufficient number of courses of curved segmented concrete block between top of vault frame to temporarily elevate vault cover to existing grade level.
5. After installation is complete, backfill and compact soil around vaults.
6. Vault size:
 - a. As indicated on the Drawings or as required for the number and size of conduits entering or as indicated on the Drawings.
 - b. Minimum floor dimension of 6 FT x 6 FT and a minimum depth of 6 FT.

3.7 UNDERGROUND CONDUITS

- A. General Installation Requirements:
 1. Ductbank types per location:
 - a. Direct-buried conduit(s):
 - 1) As indicated on the Drawings
 2. Do not place soil until conduits have been observed by the Engineer.
 3. During construction and after conduit installation is complete, plug the ends of all conduits.
 4. Provide conduit supports and spacers.
 - a. Place supports and spacers for rigid nonmetallic conduit on maximum centers as indicated for the following trade sizes:
 - 1) 3-1/2 to 6 IN: 7 FT.
 - b. Securely anchor conduits to supports and spacers to prevent movement during placement of concrete or soil.
 5. Stagger conduit joints at intervals of 6 IN vertically.
 6. Make conduit joints watertight and in accordance with manufacturer's recommendations.
 7. Accomplish changes in direction of runs exceeding a total of 15 degrees by long sweep bends having a minimum radius of 25 FT.
 - a. Sweep bends may be made up of one or more curved or straight sections or combinations thereof.
 8. Furnish manufactured bends at end of runs.
 - a. Minimum radius of 48 IN for conduits 3 IN trade size and larger.
 9. Field cuts requiring tapers shall be made with the proper tools and shall match factory tapers.
 10. After the conduit run has been completed:
 - a. Clean the conduit by pulling a heavy duty wire brush mandrel followed by a rubber duct swab through each conduit.
 11. Pneumatic rodding may be used to draw in lead wire.
 - a. Install a heavy nylon cord free of kinks and splices in all unused new ducts.
 - b. Extend cord 3 FT beyond ends of conduit.
 12. Place warning tape in trench directly over ductbanks, direct-buried conduit, and direct-buried wire and cable.
- B. Direct-Buried Conduit(s):
 1. Install so that the top of the uppermost conduit, at any point:
 - a. Is not less than 36 IN below grade.
 - b. Is below pavement sub-grading.
 2. Provide a uniform minimum clearance of 2 IN between conduits.

3.8 CONDUIT FITTINGS AND ACCESSORIES

- A. Conduit Seals:
 - 1. Installed in conduit systems located in hazardous areas as required by the NFPA 70.
 - 2. Filler plug and drain shall be accessible.
 - 3. Pour the conduit seals in a two-step process.
 - a. Pour the seal and leave cover off.
 - b. After seal is dry, inspect for proper sealing, install cover and mark (for example, paint or permanent marker) as complete.
- B. Rigid nonmetallic conduit and fittings shall be joined utilizing solvent cement.
 - 1. Immediately after installation of conduit and fitting, the fitting or conduit shall be rotated 1/4 turn to provide uniform contact.
- C. Install Expansion Fittings:
 - 1. Where conduits are exposed to the sun and conduit run is greater than 200 FT.
 - 2. Elsewhere as identified on the Drawings.
- D. Install Expansion/Deflection Fittings:
 - 1. Where conduits enter a structure.
 - a. Except electrical vaults.
 - b. Except where the ductbank is tied to the structure with rebar.
 - 2. Where conduits span structural expansions joints.
 - 3. Elsewhere as identified on the Drawings.
- E. Threaded connections shall be made wrench-tight.
- F. Conduit joints shall be watertight:
 - 1. Where subjected to possible submersion.
 - 2. In areas classified as wet.
 - 3. Underground.
- G. Terminate Conduits:
 - 1. When stubbed up through the floor into floor mount equipment:
 - a. With an insulated grounding bushing on metallic conduits.
 - b. With end bells on nonmetallic conduits.
- H. Threadless couplings shall only be used to join new conduit to existing conduit when the existing conduit end is not threaded and it is not practical or possible to cut threads on the existing conduit with a pipe threader.

3.9 CONDUIT SUPPORT

- A. Permitted multi-conduit surface or trapeze type support system per area designations and conduit types:
 - 1. Dry or wet:
 - a. Galvanized system consisting of: Galvanized steel channels and fittings, nuts and hardware and conduit clamps.
 - b. Aluminum system consisting of: Aluminum channels, fittings and conduit clamps with stainless steel nuts and hardware.
 - 2. Conduit type shall be compatible with the support system material.
 - a. Fiberglass system may be used with PVC-40 and PVC-80.
- B. Permitted single conduit support fasteners per area designations and conduit types:
 - 1. Dry or wet:
 - a. Material: Zinc plated steel, stainless steel and malleable iron.
 - b. Types of fasteners: Straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
 - 2. Conduit type shall be compatible with the support fastener material.
 - a. Nonmetallic fasteners may be used with PVC-40 and PVC-80.

- C. Conduit Support General Requirements:
1. Maximum spacing between conduit supports per NFPA 70.
 2. Support conduit from the building structure.
 3. Do not support conduit from process, gas, air or water piping; or from other conduits.
 4. Provide hangers and brackets to limit the maximum uniform load on a single support to 25 LBS or to the maximum uniform load recommended by the manufacturer if the support is rated less than 25 LBS.
 - a. Do not exceed maximum concentrated load recommended by the manufacturer on any support.
 - b. Conduit hangers:
 - 1) Continuous threaded rods combined with struts or conduit clamps: Do not use perforated strap hangers and iron bailing wire.
 - c. Do not use suspended ceiling support systems to support raceways.
 - d. Hangers in metal roof decks:
 - 1) Utilize fender washers.
 - 2) Not extend above top of ribs.
 - 3) Not interfere with vapor barrier, insulation, or roofing.
 5. Conduit support system fasteners:
 - a. Use sleeve-type expansion anchors as fasteners in masonry wall construction.
 - b. Do not use concrete nails and powder-driven fasteners.
- D. Duct bank spacers
1. Maintain the separation of multiple planes of conduits by one of the following methods:
 - a. Install multilevel conduits with the use of conduit supports and separators to maintain the required separations, and backfill with flowable fill (100 PSI) or concrete.
 - b. Install the multilevel conduits one level at a time.
 - 1) Each level is backfilled with the appropriate amount of soil and compaction to maintain the required separations.

END OF SECTION

PART 3.5 - SECTION 26 08 13
ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Basic requirements for acceptance testing.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.
 - 3. Section 26 05 00 - Electrical: Basic Requirements.

1.2 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
 - b. 400.3, Guide for Partial Discharge Testing of Power Cable Systems in a Field Environment.
 - 2. Nationally Recognized Testing Laboratory (NRTL).
- B. Qualifications:
 - 1. Testing firm qualifications: See Specification Section 26 05 00.
 - 2. Field personnel:
 - a. See Specification Section 26 05 00.
 - b. As an alternative, supervising technician may be certified by the equipment manufacturer.
 - 3. Analysis personnel:
 - a. See Specification Section 26 05 00
As an alternative, supervising technician may be certified by the equipment manufacturer.
- C. Phasing Diagram:
 - 1. Coordinate with Utility Company for phase rotations and Phase A, B and C markings.
 - a. Create a phasing diagram showing the coordinated phase rotations with generators and motors through the transformers.

1.3 SUBMITTALS

- A. Shop Drawings:
 - 1. See Specification Section 26 05 00 for electrical equipment and connection testing plan submittal requirements.
- B. Informational Submittals:
 - 1. Prior to energizing equipment:
 - a. Coordinated phasing diagram.
 - b. Photocopies of continuity tests.
 - 2. Within two (2) weeks after successful completion of Demonstration Period (Commissioning Period):
 - a. Single report containing information including:
 - 1) Summary of Project.
 - 2) Information from pre-energization testing.
 - 3) See testing and monitoring reporting requirements in Specification Section 26 05 00.

PART 2 - PRODUCTS

2.1 FACTORY QUALITY CONTROL

- A. Provide Electrical equipment with all factory tests required by the applicable industry standards or NRTL.
- B. Factory testing will not be accepted in lieu of field acceptance testing requirements specified in this Specification Section and Specification Section 26 05 00.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

- A. General:
 - 1. See Specification Section 26 05 00.
 - 2. Complete electrical testing in three (3) phases:
 - a. Pre-energization testing phase.
 - 1) Verify electrical phasing prior to equipment energization.
 - b. Equipment energized with no load.
 - c. Equipment energized under load.
 - 3. Perform testing in accordance with this Specification Section and manufacturer's recommendations.
 - 4. Provide field setting and programming of all adjustable protective devices and meters to settings provided by the Engineer.
- B. Equipment Monitoring and Testing Plan: See Specification Section 26 05 00.
- C. Instruments Used in Equipment and Connections Quality Control Testing: See Specification Section 26 05 00.
- D. Testing and Monitoring Program Documentation: See Specification Section 26 05 00.
- E. Electrical Equipment and Connections Testing Program:
 - 1. See Specification Section 26 05 00.
 - 2. See individual Division 26 Specification Sections for equipment specific testing requirements.
 - 3. Test all electrical equipment per manufacturer's recommendations.

3.2 SPECIFIC EQUIPMENT TESTING REQUIREMENTS

- A. Transformers - Liquid Filled:
 - 1. Perform inspections and tests per manufacturer's recommendations.
 - 2. Components: Test all components per applicable paragraphs of this Specification Section and manufacturer's recommendations.
 - 3. Perform the following additional tests:
 - a. Record phase-to-phase, phase-to-neutral, and neutral-to-ground voltages at no load after energizing, and at operating load after start-up.
 - 4. Adjust tap changer setting as required to provide secondary voltage within 2-1/2 percent of nominal under normal load after approval of Engineer.
 - 5. Record as-left tap changer setting.
- B. Cable - Medium Voltage:
 - 1. Perform inspections and tests per manufacturer's recommendations.
 - 2. Very low frequency (VLF) test (IEEE 400.2):
 - a. Prior to energization, perform a VLF test for baseline data for future VLF maintenance testing.
 - b. VLF testing shall include:
 - 1) Withstand test to evaluate whether the cable can handle the test voltage

- 2) Tangent delta test, including differential tangent delta and tangent delta stability, for baseline comparison
 - c. Results for new cable shall be compared to Table G.2 in IEEE 400.2
3. Non-destructive partial discharge test:
 - a. After energization, perform a partial discharge test for baseline data for future partial discharge maintenance testing.
 - b. Perform the work while the medium voltage circuits and equipment are energized.
 - 1) The cables shall not be disconnected or de-energized and the testing shall not expose the cables to voltages that exceed normal operating voltage.
 - c. Use a frequency domain detection process incorporating a spectrum analyzer with radio frequency current transformer (RF CT) sensors.
 - 1) The detection system, including spectrum analyzer, RF CT's and interconnecting cable, shall have a partial discharge detection range that at least covers the frequency range of 10 kHz to 300 MHz.
 - 2) Testing shall be performed in a manner that complies with the requirements of IEEE 400 and IEEE 400.3.
- C. Medium Voltage Circuit Breakers and Vacuum Fault Interrupters:
 1. Perform inspections and tests per manufacturer's recommendations.
 2. Components: Test all components per applicable paragraphs of this Specification Section and manufacturer's recommendations.
 3. Perform the following additional tests:
 - a. High-potential vacuum integrity test per manufacturer's recommendations.
 - b. Control wiring insulation resistance.
 - c. Minimum trip and close voltage.
 - d. Overpotential.
- D. Protective Relays:
 1. Perform inspections and tests per manufacturer's recommendations.
 - a. Tests to be performed using secondary injection of 3 PH current and potential at final settings.
 - b. Test at manufacturer's recommended test points and critical timing points identified on relay setting sheet.
 2. Perform the following additional tests:
 - a. Verification of direct trip of associated lockout relay or circuit breaker(s) by using relay test function or shorting trip contact at relay case.
 - b. Microprocessor-based relays:
 - 1) Complete commissioning procedure per manufacturer's instructions, followed by tests of each relay element at final settings.
 - 2) Verification of all internally-programmed logic.
 - c. Verification of all auxiliary input and output signals.
 - d. Verification of power supply/self-diagnostic alarm contact and remote annunciation.
 3. Record as-left settings.
- E. Metering:
 1. Perform inspections and tests per manufacturer's recommendations.
 2. Components: Test all components per applicable paragraphs of this Specification Section and manufacturer's recommendations.
- F. Grounding:
 1. Perform inspections and tests per manufacturer's recommendations.
 2. Components: Test all components per applicable paragraphs of this Specification Section.

END OF SECTION

PART 3.6 - SECTION 26 12 19
DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Distribution pad-mounted transformers.
 - 2. Fiberglass Ground Sleeve
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 01 - General Requirements.
 - 2. Section 26 05 00 - Electrical: Basic Requirements.
 - 3. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. American National Standards Institute (ANSI).
 - 2. Institute of Electronic and Electronics Engineers, Inc. (IEEE):
 - a. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V.
 - b. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - c. C57.12.25, Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors; High Voltage, 34 500 Grdy/19 920 Volts and Below; Low-Voltage, 240/120 Volts; 167 kVA and Smaller
 - d. C57.12.28, Standard Requirements for Pad-Mounted Equipment - Enclosure Integrity.
 - e. C57.12.34, Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers (2500 kVa and Smaller) - High-Voltage: 34 500 GrdY/19 920 Volts and Below; Low-Voltage: 480 Volts and Below.
 - f. C57.12.70, Standard Terminal Markings and Connections for Distribution and Power Transformers.
 - g. C57.12.80, Standard Terminology for Power and Distribution Transformers.
 - h. C57.12.90, Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - i. C62.11, Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1 kV).
 - 3. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).

1.3 SUBMITTALS

- A. Shop Drawings:
 - 1. Product technical data:
 - a. Provide submittal data for all products including subcomponents specified in PART 2 of this Specification Section.
 - b. See Specification Section 26 05 00 for additional requirements.
 - 2. Fabrication and/or layout Drawings.
 - a. Outline Drawing including dimensions, weight and identification of all components and features.
 - b. Nameplate Drawing.
 - 3. Certifications:
 - a. Letter stating compliance with current Department of Energy efficiency requirements.

- B. Contract Closeout Information:
 - 1. Operation and Maintenance Data:
 - a. Content of Operation and Maintenance Manual:
 - 1) Instruction and maintenance manual.
 - 2) Product technical data provided in the submittal.
 - 3) Outline drawing updated for as-built conditions.
 - 4) Nameplate Drawing updated for as-built conditions.
 - 5) Actual impedance data.
 - 6) Factory test report.
 - 7) Acceptance testing report.
 - 8) Renewal parts lists for all replaceable parts and assemblies.
 - b. Furnish five (5) copies at least two (2) weeks prior to shipment.
- C. Informational Submittals:
 - 1. Factory test report.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. See Specification Section 26 05 00.

1.5 EQUIPMENT GUARANTEE

- A. Without limiting any other provision regarding guarantees, manufacturer shall guarantee the equipment as follows:
 - 1. Seller shall guarantee to the Owner that the equipment together with all parts included in the original purchase, is free of defect in workmanship and materials and is capable of continuous and satisfactory performance when operated in accordance with the instructions provided by the Seller at the specified rating and capacity.
 - 2. Guarantee shall extend for a minimum of one (1) year from the date of commercial operation. It shall cover all defects and malfunctions of the equipment and accessories.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Eaton Cooper Power Systems.
 - 2. ABB.
 - 3. G&W
 - 4. Howard Industries, Inc.
 - 5. Prolec GE.
 - 6. Square D Company.

2.2 THREE-PHASE TRANSFORMER

- A. General:
 - 1. Transformer to be designed and constructed in accordance with:
 - a. IEEE C57.12.00, IEEE C57.12.28, IEEE C57.12.34, IEEE C57.12.70, IEEE C57.12.80.
- B. Ratings and Configurations:
 - 1. Type: Outdoor, pad-mounted, liquid-immersed, self-cooled, compartmental type.
 - a. "Unit Residential" type padmount transformers are not acceptable.
 - 2. Operation and application: Step-down operation.
 - 3. Configuration:
 - a. Dead-front, loop-feed primary.
 - 4. Voltage:
 - a. Primary: 12.47 grounded wye/7.2 kV.
 - b. Secondary: 208Y/120V or 480Y/277V, as shown on Drawings.
 - 5. kVA Ratings: As specified on the Drawings.

6. Number of phases: Three (3), unless shown on Drawings.
7. Class: OA.
8. Frequency: 60 Hz.
9. Polarity: ANSI standard.
10. Percent impedance: ANSI standard.
11. Basic impulse level (BIL):
 - a. Primary: 95 kV
 - b. Secondary: 30kV.
12. Temperature rise: 65 DegC.
13. Efficiency: Meet all current Department of Energy rules.
14. Connections:
 - a. Wye-wye
 - b. Primary:
 - 1) 200 ampere bushing wells and insert for loadbreak elbows
 - 2) Dead front design
 - c. Secondary (208/120V):
 - 1) Less than 750 kVA: Six-hole, tin-plated, NEMA spade-type minimum or as required.
 - 2) Removable ground strap on neutral terminal.
 - d. Secondary (480/277V):
 - 1) Less than 750 kVA: Six-hole, tin-plated, NEMA spade-type minimum or as required.
 - 2) Removable ground strap on neutral terminal.
15. Tap-changer: None required
16. Sectionalizing oil immersed load break primary switch:
 - a. Rating: 200A
 - b. Four (4) position, 'T' blade, with the switch positions labeled:
 - 1) "SOURCE A" (Loop is open and the coil is energized by Source A).
 - 2) "SOURCE B" (Loop is open and the coil is energized by Source B).
 - 3) "SOURCE A & B" (Loop is closed and the coil is energized by both sources).
 - 4) "LOOP CLOSED & XFMR OPEN" (Loop is closed and the coil is de-energized).
 - c. Switch shall:
 - 1) Be gang operated
 - 2) Be rotary (360 degree operation)
 - 3) Have movable index plate to limit accidental switch rotation
 - 4) Be hook stick operable
 - 5) Have permanently attached handle
 - 6) Be marked for switch position and circuit identification
 - d. Provide one-line diagram of switch arrangement mounted in clear view.

C. Components:

1. Core and Coil:
 - a. Coil material: Aluminum or copper.
 - b. Windings:
 - 1) Designed to reduce losses.
 - 2) Connected for grounded-wye to grounded-wye operations
 - 3) Two winding type construction
 - 4) Autotransformers are not allowed.
 - c. Insulating materials rated for 120 DegC class.
 - d. Core material: High-grade, grain-oriented, burr-free, silicon core steel with high magnetic permeability, low hysteresis and eddy current losses.
 - e. Core frame:
 - 1) Designed to provide maximum support for the core and coil assembly.
 - 2) Welded or bolted to ensure maximum short-circuit strength.
 - f. Designed and manufactured to meet the short circuit requirements of ANSI C57.12.90.

- g. Vacuum processed and energized to set the epoxy coating on the insulating paper and remove moisture from the insulation. While energized and under vacuum, the transformer is to be filled with preheated, filtered, and degassed insulating fluid.
- h. Triplex or five legged core design.
- 2. Tank and Terminal Cabinet Enclosure:
 - a. Carbon steel reinforced with external, internal or sidewall braces, with all seams and joints continuously welded.
 - b. Design the tank and attached components to withstand 7 psi without permanent deformation, and 15 psi without rupture. The tank shall include a 15 psig pressure relief valve with a flow rate minimum of 35 SCFM.
 - c. Sealed-tank construction:
 - 1) 500kVA and below: Bolted main tank cover.
 - d. Lifting lugs welded to tank.
 - e. Steel divider between high-voltage (left side) and low-voltage (right side) compartments.
 - f. No exposed screws, bolts, or other fastening devices that are externally removable.
 - g. Tamper resistant per IEEE C57.12.28.
 - h. Cabinet depth: IEEE standard or 20 IN minimum.
 - i. 1 IN upper fill plug.
 - j. 1 IN drain valve with sampling device.
 - k. Automatic pressure relief device.
 - l. Ground pad(s):
 - 1) 500kVA and below: Two (2) steel pads with one (1) hole.
 - m. Door:
 - 1) Each compartment will have removable, three-point latching hinged doors equipped for latching in the open position.
 - 2) The high-voltage compartment door will have a fastening device that is accessible only through the low-voltage compartment.
 - 3) The hinge assemblies made of corrosion-resistant material.
 - a) Provide stainless-steel hinge pins of 3/8 IN minimum diameter.
 - 4) Both compartment doors capable of securing with a single padlock having a maximum 1/2 IN DIA shackle.
 - 5) Door secured with a penta-head bolt.
 - 6) Provisions to secure doors in open position.
 - 7) Provide 7"x10" "Caution" warning signs on exterior of all access doors.
 - n. Grounding lug attachments:
 - 1) Minimum of two welded attachments for connection to concentric neutral termination on front of tank
 - 2) Lugs shall accommodate 1/0 copper ground conductor.
- 3. Overcurrent protection:
 - a. Internal partial-range current limiting backup fuse.
 - b. Provide and install full range protection two fuse system.
 - c. Partial-range current limiting backup fuse.
 - 1) Interrupting rating: 50,000A.
 - 2) Under oil, non-field replaceable.
 - d. Dual sensing, expulsion-type, Bay-O-Net fuse.
 - e. High amp overload, expulsion-type, Bay-O-Net fuse.
 - 1) Under oil, field replaceable.
 - 2) Load break operable with hot stick.
 - 3) In series with the current limiting fuse.
 - 4) Provide Bay-O-Net assembly with flapper valve.
 - 5) Provide metal drip shield or snap on drip guard.
 - 6) Provide spare fuse element for fuse size.
- 4. Finish:
 - a. Manufacturer's standard corrosion protection system in accordance with IEEE C57.12.28.

- b. Color: Munsell Green 7GY 3.29/1.5.
- 5. Dielectric Fluid:
 - a. Tested for compatibility with the transformer.
 - b. Less-flammable, non-toxic, non-bioaccumulating, biodegradable per US EPA OPPTS 835.3100 and certified to comply with US EPA Environmental Technology Verification requirements.
 - 1) Fluid is to be 100% derived from edible seed oils and food grade performance enhancing additives.
 - 2) The fluid shall not require genetically altered seeds for its base oil.
 - c. Permanently affix nameplate stamped "Non PCB".
- 6. Accessories:
 - a. Liquid level gage
 - b. Dial-type thermometer gage.
 - c. Pressure vacuum gage
 - d. Stainless steel or laser-scribed anodized aluminum nameplate, with date of manufacturer.
 - e. Cable parking stands, one per bushing.

2.3 SINGLE PHASE TRANSFORMERS

- A. General:
 - 1. Transformer to be designed and constructed in accordance with IEEE C57.12.00, IEEE C57.12.25, IEEE C57.12.28, IEEE C57.12.70, IEEE C57.12.80.
- B. Ratings and configurations:
 - 1. Type: Outdoor, pad-mounted, liquid-immersed, self-cooled, compartmental type.
 - 2. Operation and application: Step-down operation.
 - 3. Configuration:
 - a. Dead-front, radial-feed primary.
 - b. Voltage and kVA Ratings: As specified on the Drawings.
 - c. Number of phases: One (1).
 - d. Frequency: 60 Hz.
 - e. Polarity: ANSI standard.
 - f. Percent impedance: ANSI standard.
 - g. Basic Impulse Level (BIL):
 - 1) Primary: 95 kV
 - 2) Secondary: 30 kV.
 - h. Temperature rise: 65 DegC.
 - i. Efficiency: Meet all current Department of Energy rules.
 - j. Sound Rating: Per NEMA TP 1.
 - k. Connections:
 - 1) Primary: 200 ampere bushing wells and insert for loadbreak elbows.
 - 2) Secondary: Four-hole, tin-plated, spade type.
 - l. Tap-changer: De-energized type on H-winding, five (5) total with:
 - 1) Four (4) 2.5 percent below nominal tap.
 - m. Sectionalizing oil immersed load break primary switch:
 - 1) Rating: 200A.
 - 2) Two (2) position, with the switch positions labeled:
 - a) "XFMR OPEN" when the coil is de-energized.
 - b) "XFMR CLOSED" when the coil is energized.
- C. Components:
 - 1. Core and Coil:
 - a. Coil material: Aluminum or copper.
 - b. Windings designed to reduce losses.
 - 1) Two winding type construction
 - 2) Autotransformers are not allowed.

- c. Insulating materials rated for 120 DegC class.
 - d. Core material: High-grade, grain-oriented, non-aging silicon core steel with high magnetic permeability, low hysteresis and eddy current losses.
 - e. Core frame:
 - f. Designed and manufactured to meet the short circuit requirements of ANSI C57.12.90.
 - g. Vacuum processed and energized or baked in an oven prior to tanking to set the epoxy coating on the insulating paper and remove moisture from the insulation prior to vacuum filing.
2. Tank and Terminal Cabinet Enclosure:
- a. Carbon steel reinforced with external, internal or sidewall braces, with all seams and joints continuously welded.
 - b. Stainless steel reinforced with external, internal or sidewall braces, with all seams and joints continuously welded.
 - c. Design the tank and attached components to withstand pressures greater than the required operating design value without permanent deformation.
 - d. Sealed-tank construction.
 - e. No exposed screws, bolts, or other fastening devices that are externally removable.
 - f. No openings through which foreign objects such as sticks, rods, or wires may contact live parts.
 - g. Recessed, stainless steel lifting lug receptacles.
 - h. Tamper resistant per IEEE C57.12.28.
 - i. 16 IN deep cabinet (minimum)
 - j. Oil level / fill plug.
 - k. Oil drain plug with sampling device.
 - l. Automatic pressure relief device.
 - m. Minimum of two steel tapped ground pads.
3. Door:
- a. Hinged flip-top.
 - b. Removable stainless steel hinge pins.
 - c. Pad lock provisions.
 - d. Door secured with a penta-head bolt.
 - e. Provide 7"x10" "Caution" warning signs on exterior of all access doors.
4. Overcurrent protection:
- a. Internal partial-range current limiting backup fuse.
 - b. Provide and install full range protection two fuse system.
 - c. Partial-range current limiting backup fuse.
 - 1) Interrupting rating: 50,000A.
 - 2) Under oil, non-field replaceable.
 - d. Dual sensing, expulsion-type, Bay-O-Net fuse.
 - 1) Under oil, field replaceable.
 - 2) Load break operable with hot stick.
 - 3) In series with the current limiting fuse.
 - 4) Provide Bay-O-Net assembly with flapper valve.
 - 5) Provide metal drip shield or snap on drip guard.
 - 6) Provide spare fuse element for fuse size.
5. Dielectric Fluid:
- a. Tested for compatibility with the transformer.
 - b. Less-flammable, non-toxic, non-bioaccumulating, biodegradable per US EPA OPPTS 835.3100 and certified to comply with US EPA Environmental Technology Verification requirements.
 - 1) Fluid is to be 100% derived from edible seed oils and food grade performance enhancing additives.
 - 2) The fluid shall not require genetically altered seeds for its base oil.
 - c. Permanently affix nameplate stamped "Non PCB".
6. Finish:

- a. Manufacturer's standard corrosion protection system in accordance with IEEE C57.12.28.
 - b. Color: Munsell Green 7GY 3.29/1.5
- 7. Accessories:
 - a. Cable parking stands.
 - b. Stainless steel or laser-scribed anodized aluminum nameplate, with date of manufacturer.

2.4 INSULATING SECONDARY COVERS

- A. Insulated secondary covers shall be included on all secondary terminals.
- B. Covers shall be installed over terminals and cable, without the need to remove cables.
- C. Rated for 600V minimum.

2.5 SURGE ARRESTERS

- A. Surge arresters shall be included on all radial fed or normal open, looped transformers.
- B. Arresters may be either elbow or parking stand type.
 - 1. See Section 26 05 13 for arrester requirements.

2.6 SOURCE QUALITY CONTROL

- A. Factory Tests: At a minimum, provide all routine tests as specified in IEEE C57.12.00 in accordance with IEEE C57.12.90.

2.7 MAINTENANCE MATERIALS

- A. Touch-up paint, two (2) separate one (1) quart containers.

2.8 PAD GROUND SLEEVE

- A. Owner prefers cast concrete.
 - 1. With Owner approval, fiberglass ground sleeves are acceptable when not subject to damage by snow removal or grounds keeping.
- B. Pad dimensions shall be determined by the equipment dimensions, weight of equipment and pulling sheave radius.
- C. Approved fiberglass manufacturers:
 - 1. Nordic Fiberglass
 - 2. Hubbell
 - 3. Highline Products
 - 4. Or approved equal.
- D. Fiberglass Ground Sleeve Requirements:
 - 1. Fiberglass construction
 - 2. Fire retardant resin
 - 3. 18 inch minimum depth
 - 4. Sized to fit sectionalizing enclosure
 - 5. Adequately reinforced to support sectionalizing enclosure and ancillary equipment.
 - 6. Color: Green to match equipment.
- E. Concrete pads
 - 1. Concrete mix shall be designed for the intended purpose and have the following minimum design parameters:
 - a. Minimum cement content of six (6) sacks per cubic yard
 - b. Maximum water content of six (6) gallons per sack
 - c. Minimum 28 day compressive strength of 4,000 PSI
 - d. Slump ranges from 2 to 4 inches
 - e. Air content shall be 5 percent by volume

2.9 FAULT INDICATORS

- A. General Description:
 - 1. Fault indicators shall be completely self-contained, requiring no external wiring.
 - 2. Units shall be sealed and suitable for installation in wet locations.
 - 3. Fault indicators shall be automatically resetting requiring no external tools for resetting.
- B. Electrical Characteristics:
 - 1. Nominal voltage 15 kV, BIL 95 kV, 60 Hz
 - 2. Trip current ratings: 300 amps.

2.10 METERING EQUIPMENT

- A. Meters shall be:
 - 1. Class 20 CT rated
 - 2. Form 9S
 - 3. Three-phase, four-wire wye
 - 4. 120V or 277V, as required
 - 5. Three Stator
 - 6. KWH/KW demand meter
- B. Meters shall be programmable type with KYZ pulse initiators.
 - 1. Pulse output ratios shall be programmable.
- C. Meter sockets shall be:
 - 1. 13 terminal with circuit closing devices and 10 pole test switch installed.
 - 2. Rated 100 amps continuous current.
- D. Current transformers shall be:
 - 1. Meter accuracy class.
 - 2. Suitable for clamping to the transformer secondary bushings.
 - 3. Ratioed for the nearest standard ratio below the rated full load current of the transformer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install on pad as detailed on the Drawings and in accordance with NFPA 70 and manufacturer's instructions.
- B. Transformer locations as shown on the Drawings are intended to be used as a guide.
 - 1. Field conditions may affect actual transformer location.
 - 2. Coordinate final location with Owner.
 - 3. Transformers shall be positioned so that switch-operating and elbow removal can be completed without interference of an 8-foot hot stick.
- C. Bollards:
 - 1. If installed, shall not impede operation of doors or switches.
 - 2. Transformer doors shall be able to be opened at least 90 degrees to provide access to the inside of the transformer.

3.2 FIELD QUALITY CONTROL

- A. Acceptance Testing: See Specification Section 26 08 13.

3.3 FINAL ACCEPTANCE

- A. Owner will not accept equipment as final until equipment is ascertained to be in conformance with specifications and guarantees.
- B. Upon shipment of equipment, drawings, instruction books, and test reports as required by these specifications, the Seller shall submit to the Owner a detailed statement of equipment shipped.

PART 4 - EQUIPMENT

4.1 PROPOSED TRANSFORMER SCHEDULE

A. See Drawings

END OF SECTION

PART 3.7 - SECTION 26 13 16
PAD-MOUNTED SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Load interrupter switchgear.
 - 2. Fiberglass Ground Sleeve.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Division 01 - General Requirements.
 - 2. Section 26 05 00 - Electrical: Basic Requirements.
 - 3. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. American National Standards Institute (ANSI).
 - 2. Institute of Electronic and Electronics Engineers, Inc. (IEEE):
 - a. C37.74, Standard for Load Interrupter Switchgear and Fused Load Interrupter Switchgear For Alternating Current Systems up to 38 kV.
 - 3. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - 4. Underwriters Laboratories, Inc. (UL):
 - a. Switchgear to be UL Listed
 - 1) Voltage rating
 - 2) 600A continuous current rating
 - 3) Symmetrical Interrupting rating
 - 4) Fluid Dielectrics
 - 5) Steel construction
 - 6) Controls

1.3 SUBMITTALS

- A. Shop Drawings:
 - 1. Product technical data including:
 - a. Provide submittal data for all products specified in PART 2 of this Specification Section.
 - b. Nameplate data for all equipment.
 - c. Mounting details and loading information for foundation design.
 - d. Installation instructions and procedures.
 - e. See Specification Section 26 05 00 for additional requirements.
 - 2. Fabrication and/or layout drawings:
 - a. General arrangement plan view showing door swings, cable entrance locations, shipping splits, etc.
 - b. Cross sections, elevations and details.
 - c. Complete single-line diagram.
 - d. Auxiliary and control system wiring diagrams (e.g., heaters).
 - 3. Test reports:
 - a. Certified reports of all factory production tests.
- B. Contract Closeout Information:
 - 1. Operation and Maintenance Data.

1.4 DELIVERY, STORAGE AND HANDLING

- A. See Specification Section 26 05 00.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Eaton Cooper.
 - 2. G&W Electric, Inc.
 - 3. ABB.
 - 4. General Electric Company.
 - 5. S&C Electric Company.
 - 6. Square D Company.
 - 7. Siemens.

2.2 LOAD INTERRUPTER SWITCHGEAR

- A. Ratings:
 - 1. Voltage: 15 kV
 - 2. Amperage: 600A
 - 3. Number of phases: Three (3).
 - 4. Number of wires: Three (3).
 - 5. Frequency: 60 Hz.
 - 6. Grounding system: Solid.
 - 7. Short circuit:
 - a. Fault closing and momentary: 16 kA
 - b. Short time (2 second): 10 kA
 - c. 3 shot make and latch Asymmetrical: 16 kA
 - 8. Basic impulse level: 95 kV
- B. Construction:
 - 1. Standards: IEEE C37.74.
 - 2. Liquid filled unit with a tamperproof bolted tank cover design housing load interrupter switches with or without fuses.
 - 3. Front and rear access.
 - 4. Construction shall be of mild steel with stainless steel hardware.
 - 5. Hinged doors with provisions for padlocking.
 - 6. Source and tap doors able to fully open at the same time.
 - 7. Switches:
 - a. Provisions to padlock switch in open or closed position.
 - b. OPEN-CLOSED switch position indicators.
 - c. Grounding point to allow grounding cables to be installed with the switch in the open position and the switch door closed and locked.
 - d. Fuse storage provisions when section contains fuses.
 - 8. Bushings
 - a. Deadfront type
 - b. Continuous current ratings:
 - 1) Source ways: 600A
 - 2) Tap ways: 600A
 - 3) Cabinet to allow space for 200A termination either via back of 600A termination or 600A to 200A reducer.
 - 9. Enclosure:
 - a. NEMA 3R non-walk-in, for exterior locations.
 - 1) Sloped roof.

- 2) Screened opening to prevent entrance of rodents.
- 10. External nameplate with switchgear ratings, model number, serial number, manufacturer name and date of manufacture.
- 11. Interior and exterior steel surfaces cleaned and painted with rust inhibiting primer and manufacturer's standard paint.
 - a. Finish color: Munsell Green 7GY 3.29/1.5.
 - b. Coating system to meet or exceed IEEE Std C57.12.28 standard coating system requirements for underground distribution equipment.
- C. Load Interrupter Switches:
 - 1. Configuration as indicated on the Drawings.
 - 2. Three-pole gang operated.
 - 3. Two-position (open/closed).
 - 4. Manual quick-make, quick-break utilizing a heavy-duty coil spring to provide openings and closing energy.
 - 5. Switch mechanism shaft is driven by a metal-to-metal linkage from the operating handle.
 - 6. The opening and close of the switch shall be independent of the speed at which the handle is moved.
 - 7. One main contact per phase, auxiliary break or arcing contacts shall not be permitted
 - 8. Insulating barriers between each phase and/or enclosure per manufacturer standards.
- D. Dielectric Fluid:
 - a. Tested for compatibility with the switchgear.
 - b. Less-flammable, non-toxic, non-bioaccumulating, biodegradable per US EPA OPPTS 835.3100 and certified to comply with US EPA Environmental Technology Verification requirements.
 - 1) Fluid is to be 100% derived from edible seed oils and food grade performance enhancing additives.
 - c. Permanently affix nameplate stamped "Non PCB".

2.3 PAD GROUND SLEEVE

- A. Owner prefers cast concrete.
 - 1. With Owner approval, fiberglass ground sleeves are acceptable when not subject to damage by snow removal or grounds keeping.
- B. Pad dimensions shall be determined by the equipment dimensions, weight of equipment and pulling sheave radius.
- C. Approved manufacturers:
 - 1. Nordic Fiberglass
 - 2. Hubbell
 - 3. Highline Products
 - 4. Or approved equal.
- D. Fiberglass Ground Sleeve Requirements:
 - 1. Fiberglass construction
 - 2. Fire retardant resin
 - 3. 36 inch minimum depth
 - 4. Sized to fit sectionalizing enclosure
 - 5. Adequately reinforced to support sectionalizing enclosure and ancillary equipment.
 - 6. Gel coat for UV protection
 - 7. Flange at base of sleeve to distribute weight and improve equipment settling
 - 8. Color:
 - a. Green to match equipment
- E. Concrete pads
 - 1. Concrete mix shall be designed for the intended purpose and have the following minimum design parameters:

- a. Minimum cement content of six (6) sacks per cubic yard
- b. Maximum water content of six (6) gallons per sack
- c. Minimum 28 day compressive strength of 4,000 PSI
- d. Slump ranges from 2 to 4 inches
- e. Air content shall be 5 percent by volume

2.4 FAULT INDICATORS

- A. General Description:
 - 1. Fault indicators shall be completely self-contained, requiring no external wiring.
 - 2. Units shall be sealed and suitable for installation in wet locations.
 - 3. Fault indicators shall be automatically resetting requiring no external tools for resetting.
- B. Electrical Characteristics:
 - 1. Nominal voltage 15 kV, BIL 95 kV, 60 Hz
 - 2. Trip current ratings: 300 amps.

2.5 SOURCE QUALITY CONTROL

- A. Switchgear factory tests in accordance with IEEE and ANSI standards.

2.6 MAINTENANCE MATERIALS

- A. Touch-up paint.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
 - 1. Arrange as shown on the Drawings.
- B. Supply preliminary drawings, including dimensions, to allow for completion of final layout drawings.
- C. Installation to be outdoors:
 - 1. Provide NEMA 3R non-walk-in enclosure.
 - 2. Install on fiberglass ground sleeve, align all sides of the switchgear 3 IN from top edge of sleeve and securely bolt to sleeve.
- D. Miscellaneous:
 - 1. Paint any scratched surfaces with touch-up paint.
 - 2. Tag switchboard and all circuit breakers per Specification Section 26 05 00.
- E. Construction Coordination:
 - 1. Provide complete installation and startup.
 - a. Coordinate final testing.

3.2 FIELD QUALITY CONTROL

- A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.
- B. Acceptance Tests: See Specification Section 26 08 13.

3.3 TRAINING

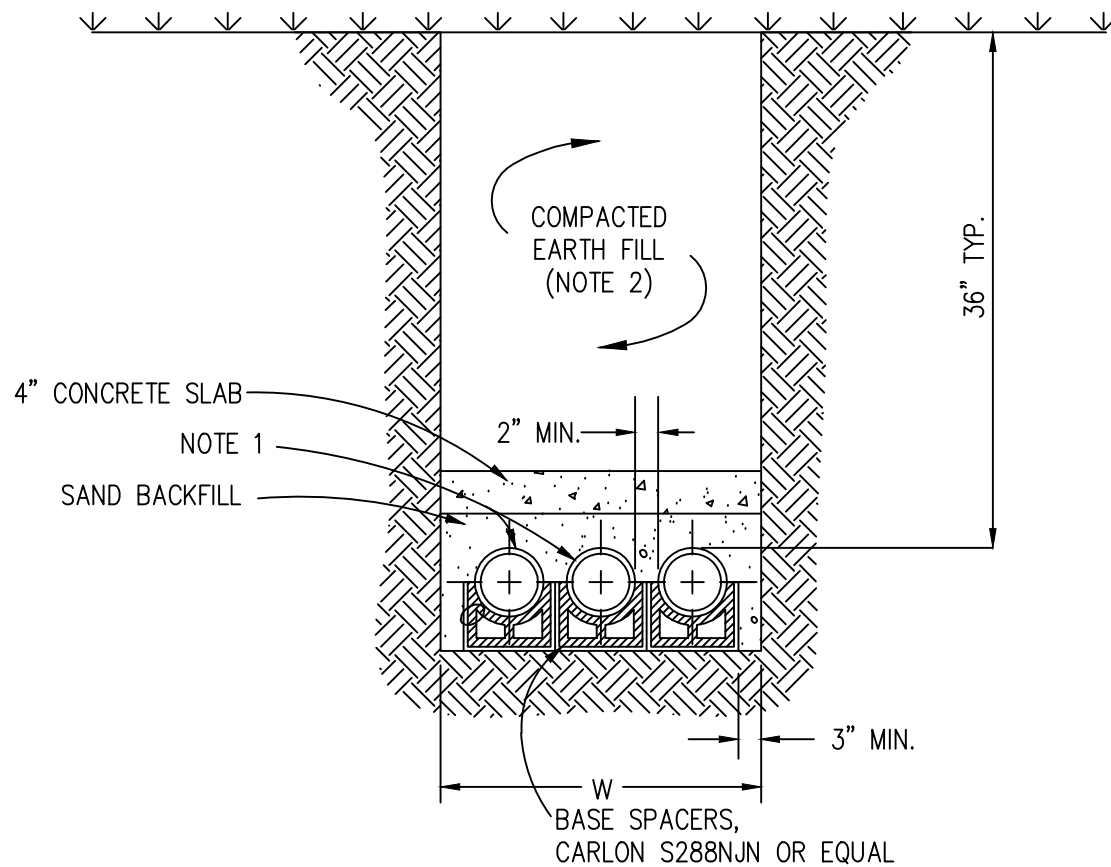
- A. A qualified factory-trained manufacturer's representative shall provide the Owner with 4 HRS of on-site training in the operation and maintenance of the switchgear and its components.

END OF SECTION

PART 4 - TYPICAL CONSTRUCTION DRAWINGS

<u>DRAWING DESCRIPTION</u>	<u>PAGE</u>
Trench and Duct Bank Detail (New Route)	IV-1
Trench and Duct Bank Detail (Over Existing Duct Bank)	IV-2
Equipment Vault	IV-3
Transformer Vault and Pad (Concrete)	IV-4
6 FT x 8 FT Vault	IV-5
Three-phase Transformer	IV-6
Single-phase Transformer	IV-7
Switchgear – Single Sided	IV-8
Switchgear – Double Sided	IV-9
Three-phase Metering	IV-10
Single-phase Metering	IV-11
Primary Cable Splice	IV-12
Elbow Connectors	IV-13
Load Break Termination Bushings and Caps	IV-14
Grounding Assemblies	IV-15
Fault Indicators and Arresters	IV-16
Three Phase Transformer (Fiberglass Pedestal)	IV-17
Cable Terminal Pole	IV-18
Tangent Pole Top Assembly, C1.11	IV-19
Angle Pole Top Assembly, C2.21	IV-19
Angle Pole Top Assembly, C3.1	IV-20
Deadend Pole Top Assembly, C5.31	IV-20
Guy Assembly, E1.1	IV-21
Anchor Assembly, F2.8	IV-21
Stringing Charts	IV-22 & IV-23
One-Line Operating Diagram	IV-24

END OF SECTION



- NOTES:
- 1. ADJUST CONDUIT SPACING, DEPTH, AND ALIGNMENT AS NECESSARY FOR MANHOLE ENTRANCE.
 - 2. BACKFILL MATERIAL SHALL BE COMPACTED TO A MINIMUM OF 95% OF MAXIMUM DRY DENSITY AS DETERMINED BY STANDARD PROCTOR TEST.

NO. CONDUITS	W (INCHES)
1	12"
2	18"
3	24"



PROJECT MANAGER B. HANSON			DESIGNED BY	
			DRAWN BY	
			CHECKED BY	
2	2-18	BROUGHT UP TO DATE		
1	4-07	BROUGHT UP TO DATE		
ISSUE	DATE	DESCRIPTION	PROJECT NUMBER	SOM-004

MONTANA STATE UNIVERSITY

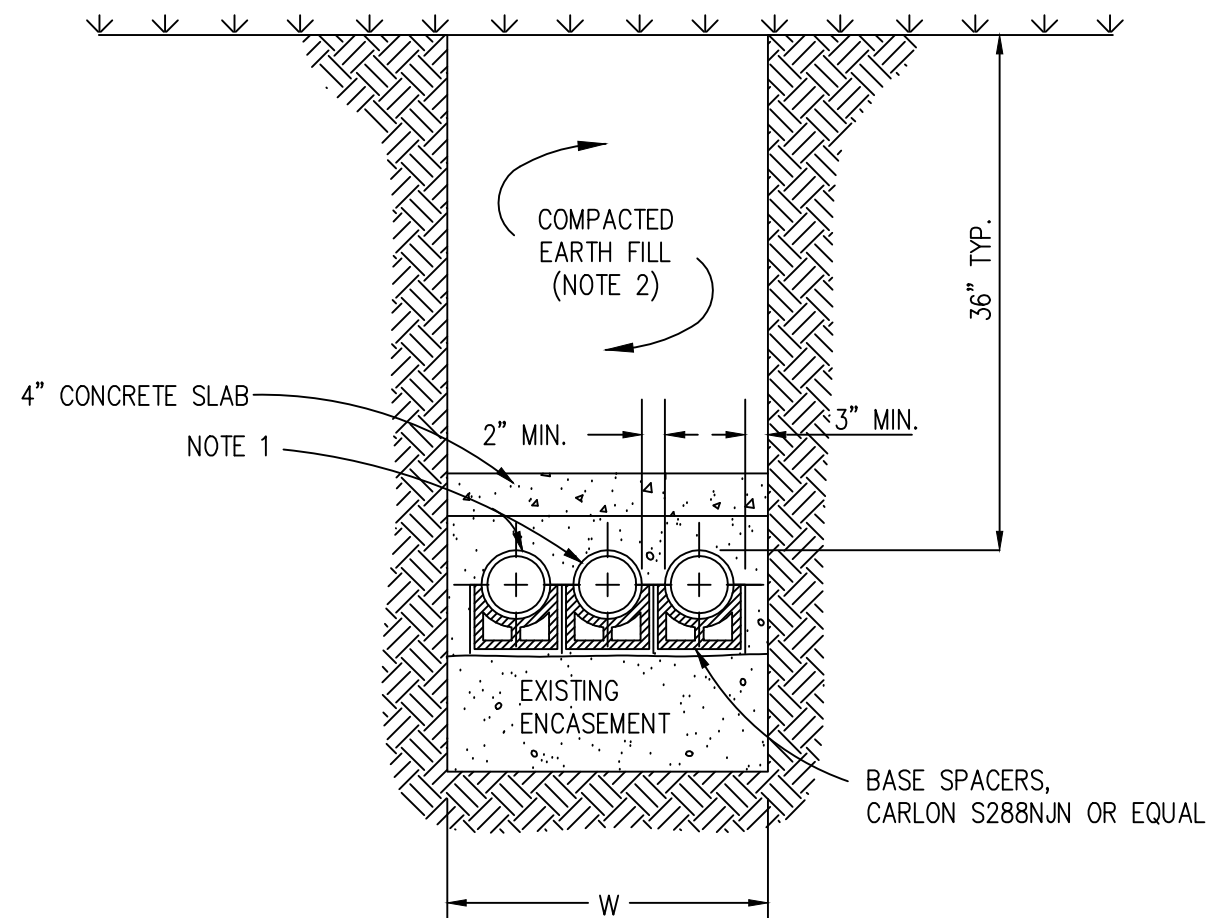
BOZEMAN, MONTANA

TRENCH AND DUCT BANK
NEW ROUTE

01"2"

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SHEET
IV-1



NO. CONDUITS	W (INCHES)
1	12"
2	18"
3	24"

- NOTES:
- ADJUST CONDUIT SPACING, DEPTH, AND ALIGNMENT AS NECESSARY FOR MANHOLE ENTRANCE.
 - BACKFILL MATERIAL SHALL BE COMPACTED TO A MINIMUM OF 95% OF MAXIMUM DRY DENSITY AS DETERMINED BY STANDARD PROCTOR TEST.



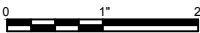
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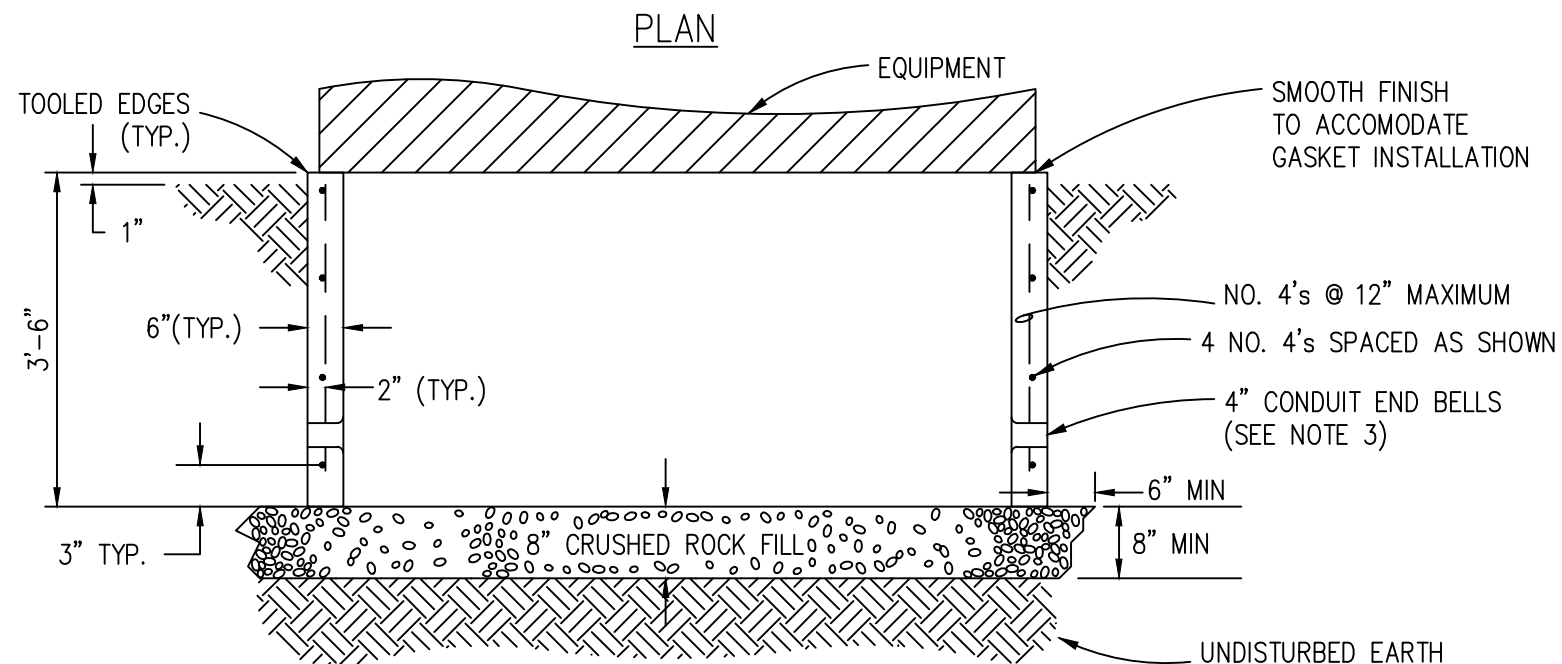
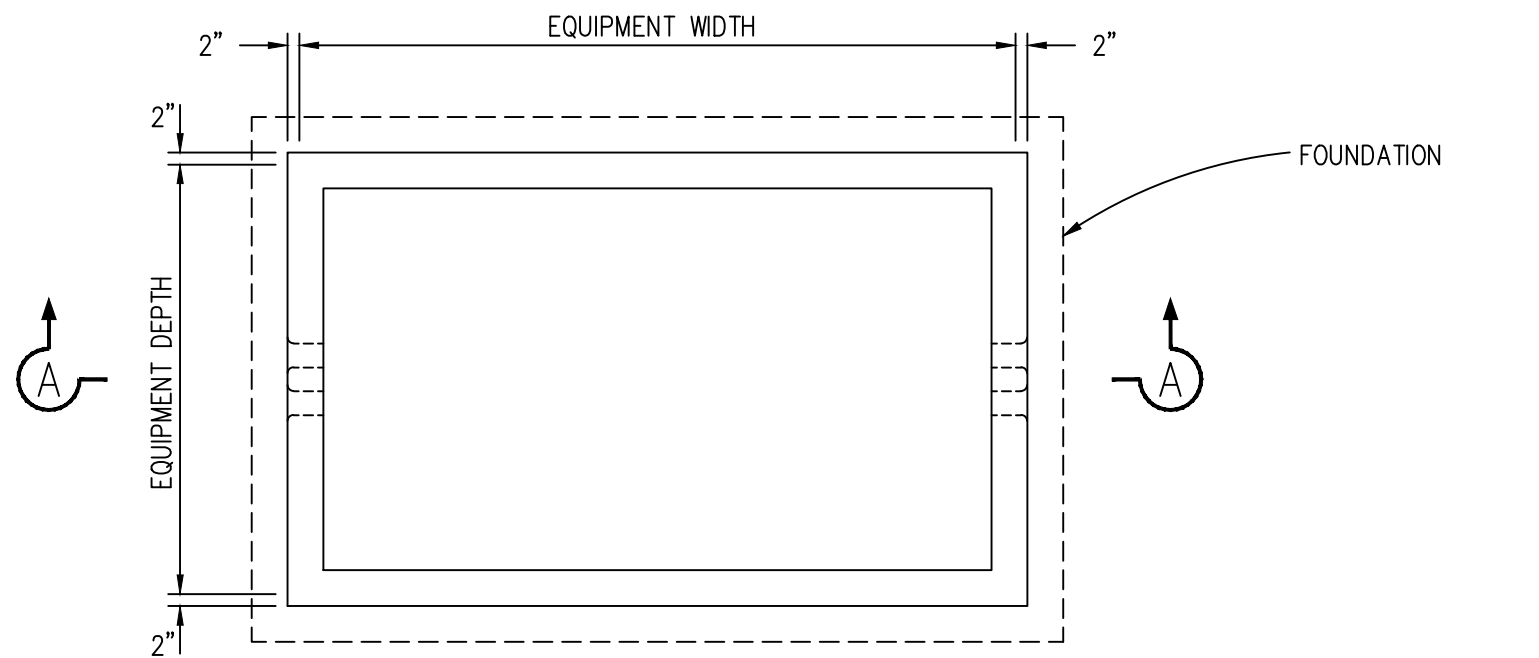
BOZEMAN, MONTANA

TRENCH AND DUCT BANK
OVER EXISTING DUCT BANK



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IV-2



NOTES:

1. ALL DISTURBED EARTH SHALL BE COMPACTED TO A MINIMUM OF 90% MAXIMUM DRY DENSITY AS DETERMINED BY THE MODIFIED PROCTOR TEST.
2. CRUSHED ROCK FILL SHALL MEET GRADATION REQUIEMENTS AS DESCRIBED IN THE WRITTEN SPECIFICATIONS.
3. CONDUIT ENTRANCE LOCATIONS MAY BE ANY COMBINATION OF THE FOUR SIDES OF THE VAULT. CONTRACTOR SHALL DETERMINE REQUIRED QUANTITY AND PROPERLY LOCATE EMBEDDED CONDUIT END BELLS TO COORDINATE WITH CONDUIT RUNS.



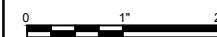
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1	4-07	BROUGHT UP TO DATE

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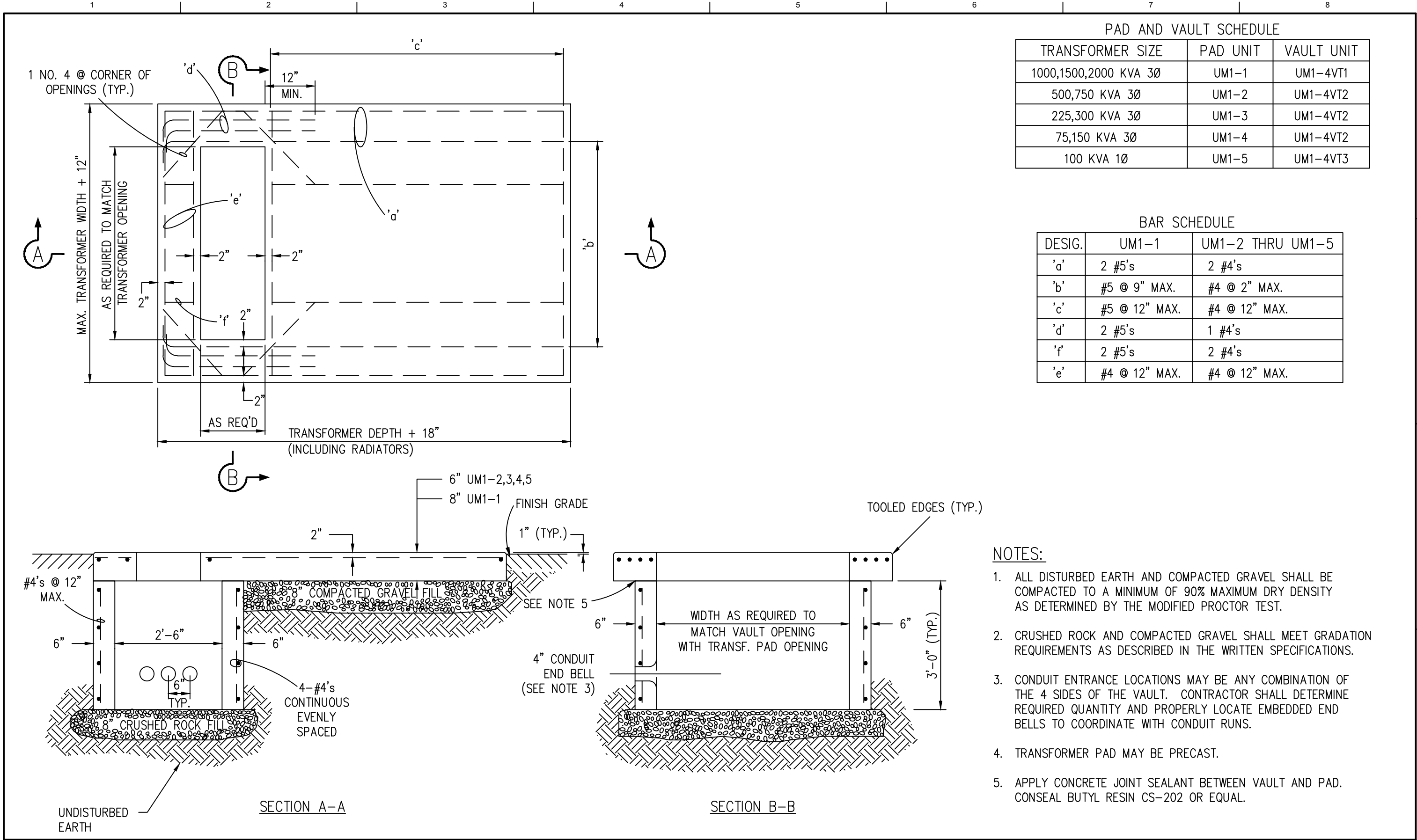
EQUIPMENT VAULT



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SHEET

IV-3



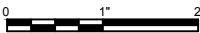
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1	4-07	BROUGHT UP TO DATE
ISSUE	DATE	DESCRIPTION

PROJECT MANAGER B. HANSON	
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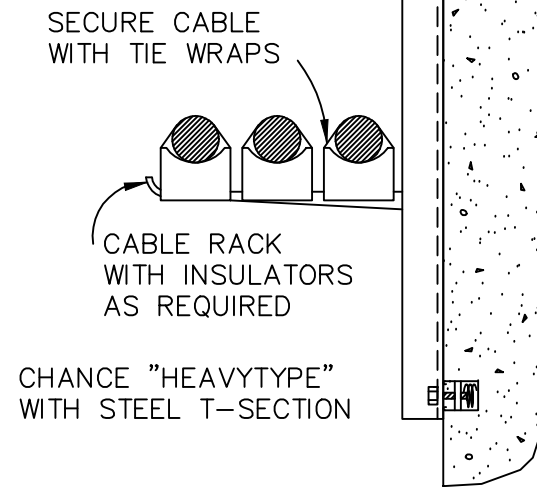
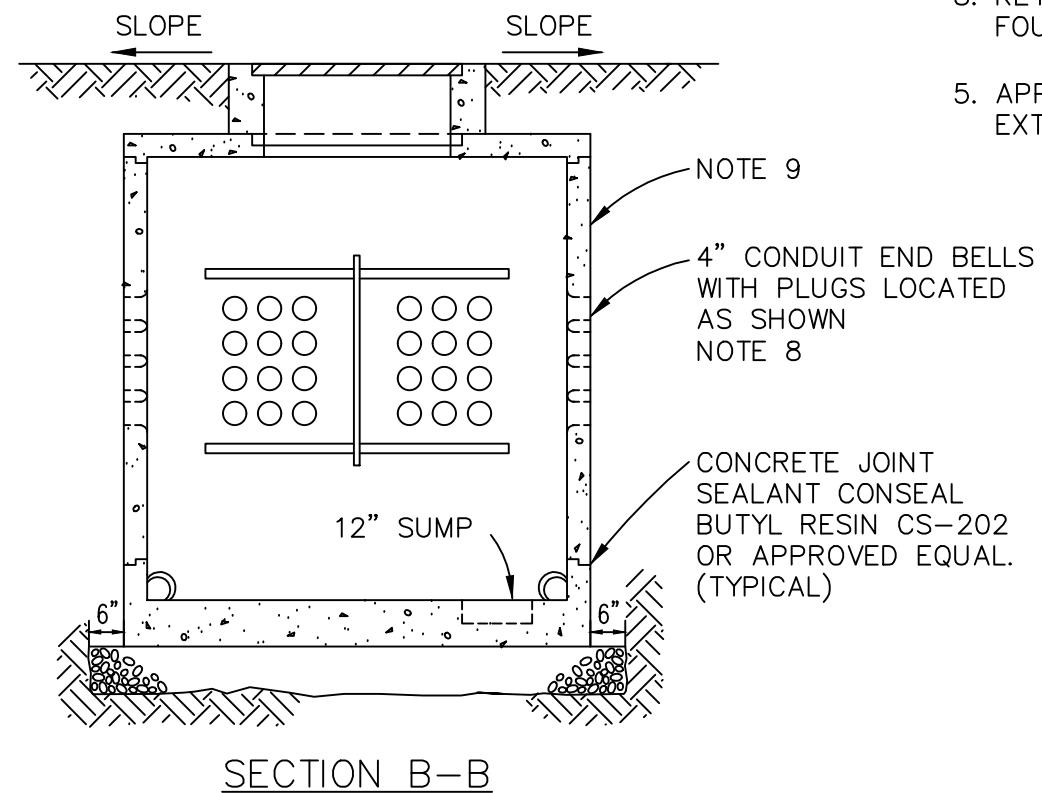
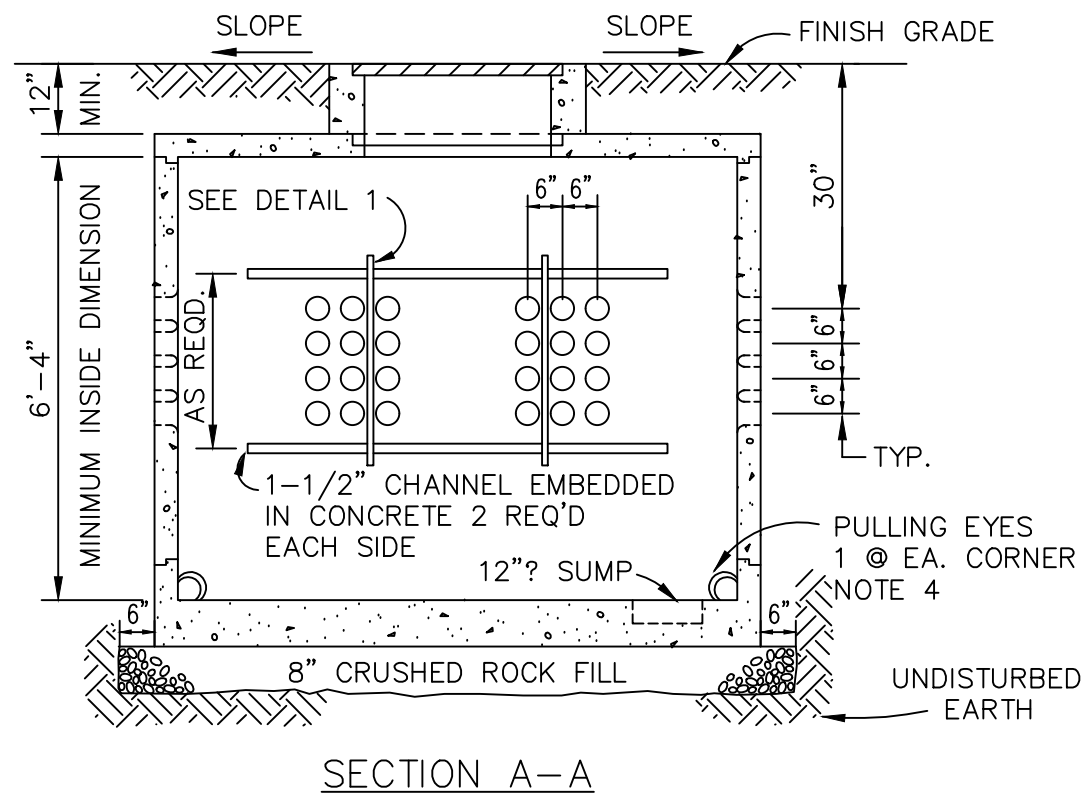
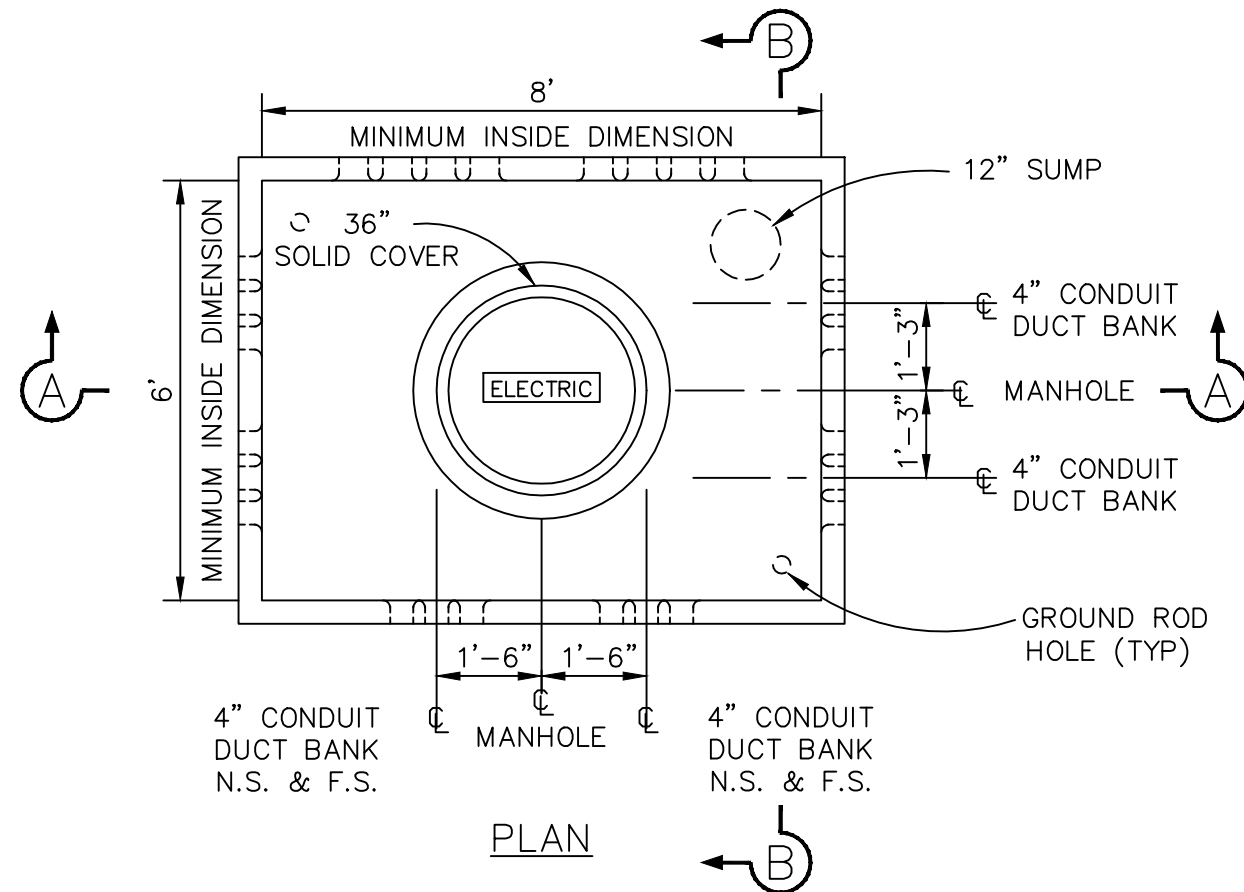
TRANSFORMER PADS AND VAULTS
CONCRETE



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SHEET

IV-4



NOTES

1. THE MANHOLE SHALL BE CONSTRUCTED OF PREFABRICATED CONCRETE SECTIONS CAPABLE OF QUICK FIELD ASSEMBLY.
2. ALL JOINTS SHALL BE GASKETED TO FORM A WEATHER TIGHT SEAL.
3. MANHOLE COVER AND STRUCTURAL SECTIONS SHALL BE DESIGNED FOR AASHTO-HS20-44 LOADING APPLIED AT FINISH GRADE.
4. PULLING EYES SHALL BE CAPABLE OF 5000 LB. WORKING TENSION.
5. MANHOLE SHALL BE PLUMBED WITHIN 1" HORIZONTAL IN 10FT. VERTICAL.
6. ALL DISTURBED EARTH SHALL BE COMPACTED TO A MINIMUM OF 90% MAXIMUM DRY DENSITY AS DETERMINED BY THE MODIFIED PROCTOR TEST.
7. CRUSHED ROCK FILL SHALL MEET GRADATION REQUIREMENTS AS DESCRIBED IN THE WRITTEN SPECIFICATIONS.
8. KEY DUCT BANK INTO MANHOLE WALL FOUR PLACES.
9. APPLY CONCRETE SEALANT TO EXTERIOR SURFACE.

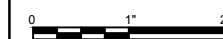


PROJECT MANAGER B. HANSON			DESIGNED BY	
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2	2-18	BROUGHT UP TO DATE		
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ISSUE	DATE	DESCRIPTION	PROJECT NUMBER	SOM-004

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BOZEMAN, MONTANA

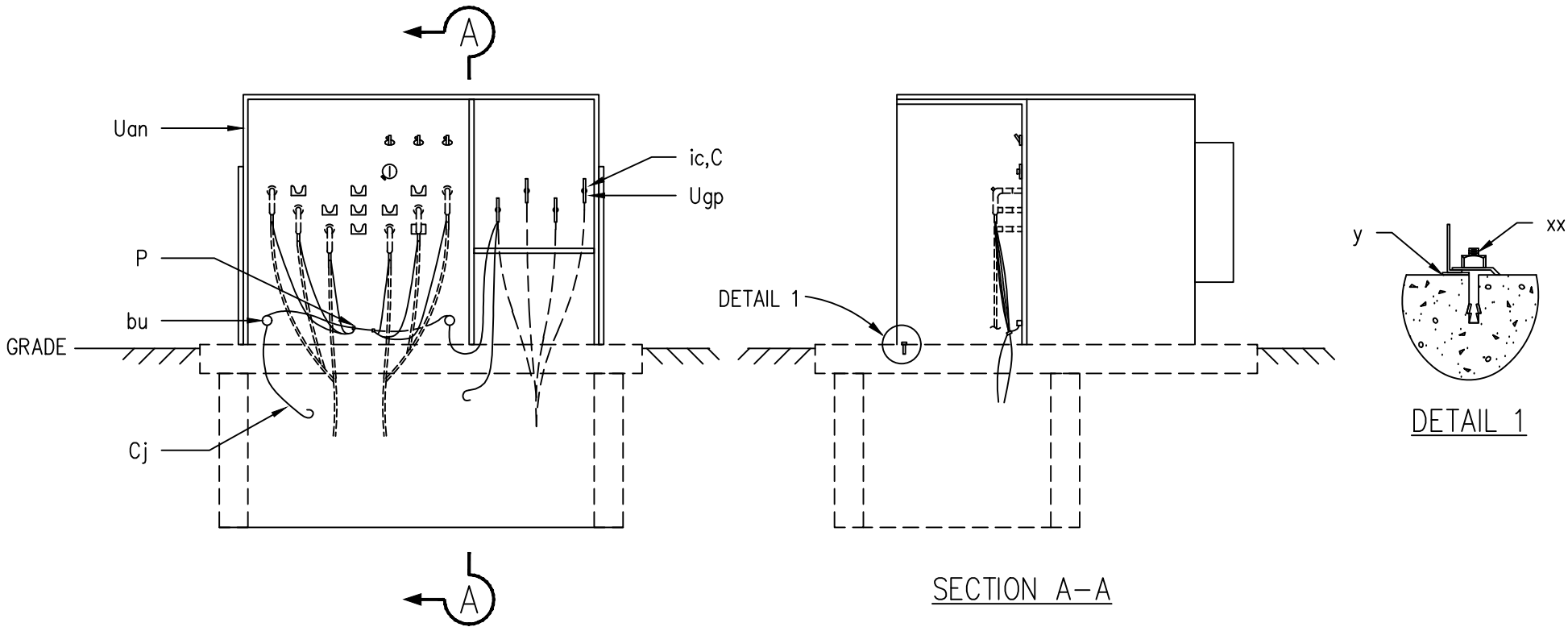
6 FT. x 8 FT. VAULT



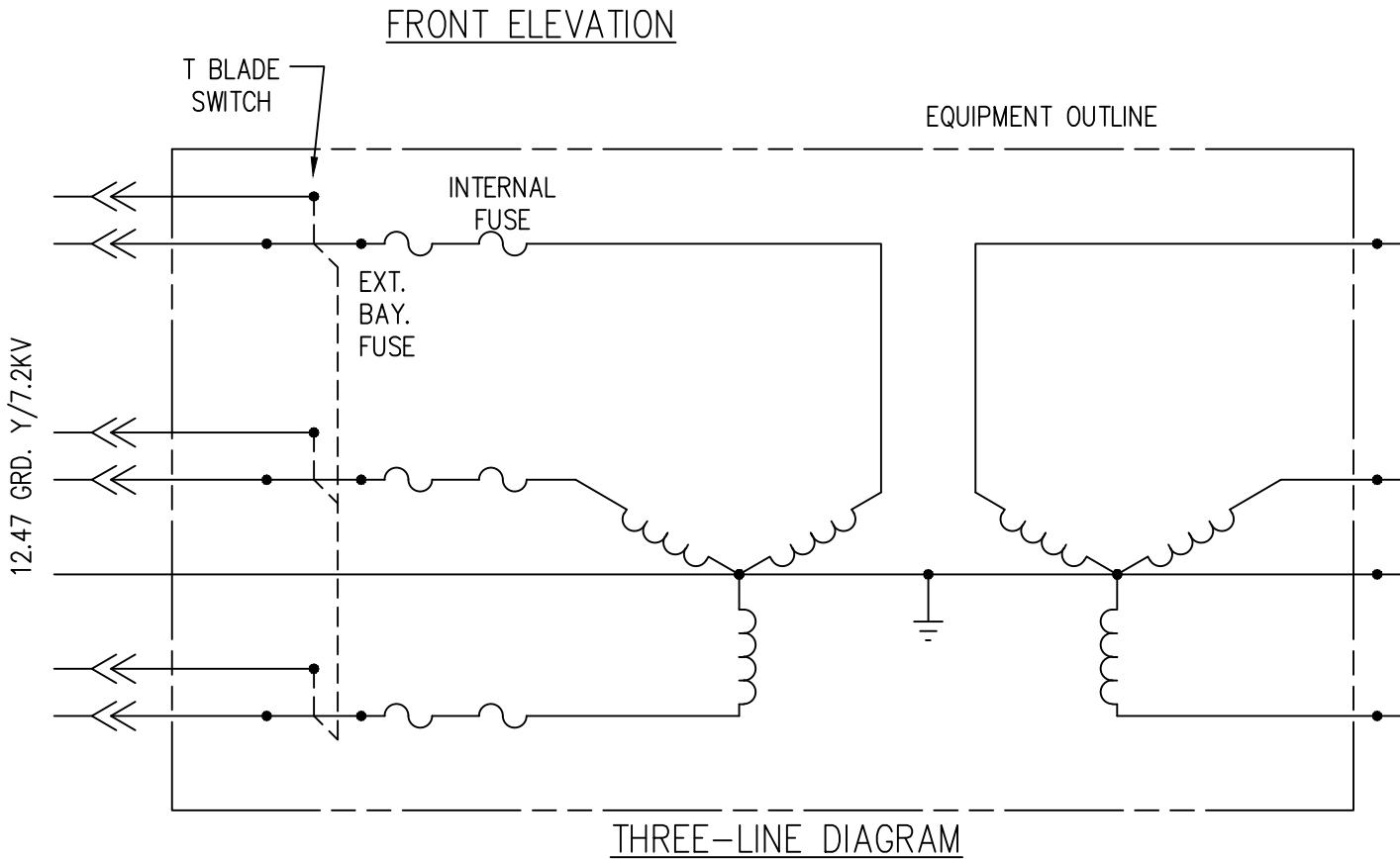
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IV-5



ITEM	NO.	MATERIAL
Uan	1	TRANSFORMER, PAD MOUNTED, 3 PHASE
bu	2	CONNECTOR, EQUIPMENT GROUND, BLACKBURN TYPE TTC2P OR APPROVED EQUAL
Cj	AS REQ'D	GROUND WIRE, 1/0 STRANDED CU.
P	AS REQ'D	CONNECTORS, COMPRESSION TYPE, COPPER, BLACKBURN TYPE CF2020 OR EQUAL
xx	2	1/2"x2" EXPANSION STUD ANCHOR, WITH ONE NUT AND WASHER
y	AS REQ'D	EQUIPMENT JOINT FILLER, URETHANE, SIKAFLEX 1A OR EQUAL
Ugp	4	CONDUCTOR TERMINAL, NEMA 2-HOLE PAD. ANDERSON TYPE L, OR APPROVED EQUAL.
C	4	PLATED BRONZE BOLT, NUT, AND BELLEVILLE WASHER
ic	4	INSULATING COVER, 600 VOLT



- NOTES:
1. UNIT INCLUDES INSTALLATION OF EQUIPMENT AND MATERIAL LISTED.
 2. PROVIDE SUFFICIENT SLACK IN PRIMARY NEUTRAL PIGTAIL AND CABLE TO PERMIT READY DISCONNECTION OF ELBOW AND MOUNTING ON PARKING STAND OR OPPOSITE BUSHING.
 3. UNIT INCLUDES TERMINATION OF NEW OR EXISTING SECONDARY SERVICE CONDUCTORS.
 4. UNIT INCLUDES STENCILLING SYSTEM STATION NUMBERS ON INTERIOR AND EXTERIOR OF ENCLOSURE.
 5. JOINT FILLER SHALL BE INSTALLED TO MAKE WATER TIGHT INSTALLATION.



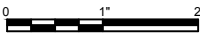
2	2-18	BROUGHT UP TO DATE
1	4-07	BROUGHT UP TO DATE
ISSUE	DATE	DESCRIPTION

PROJECT MANAGER B. HANSON	
DESIGNED BY	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	SOM-004

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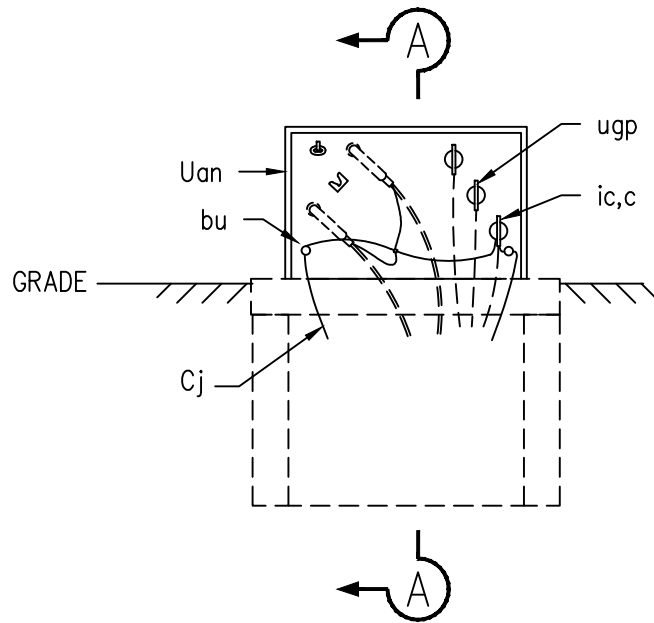
BOZEMAN, MONTANA

THREE PHASE TRANSFORMER

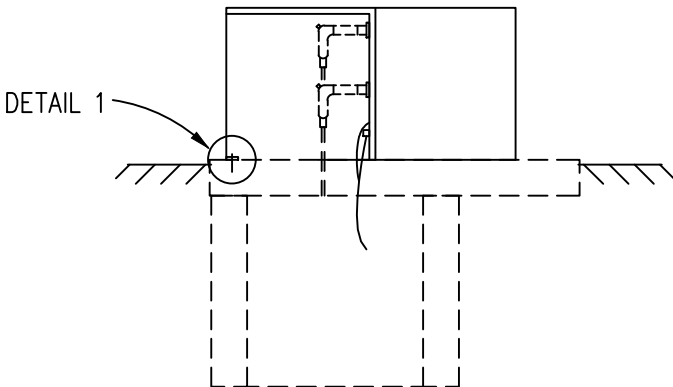


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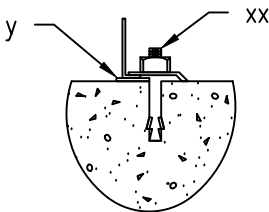
SHEET
IV-6



FRONT ELEVATION

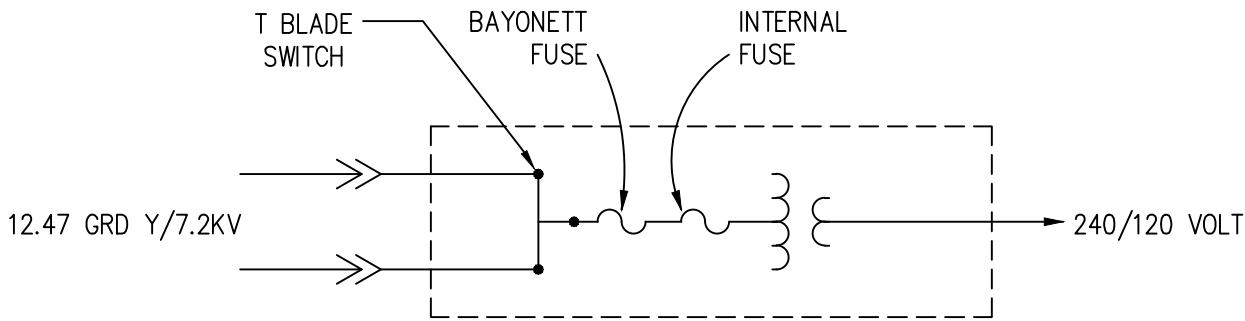


SECTION A-A



DETAIL 1

ITEM	NO.	MATERIAL
Uan	1	TRANSFORMER, PAD MOUNTED, 1 PHASE
bu	2	CONNECTOR, EQUIPMENT GROUND, BLACKBURN TYPE TTC2P OR APPROVED EQUAL
Cj	AS REQ'D	GROUND WIRE, 1/0 STRANDED – CU.
P	AS REQ'D	CONNECTORS, COMPRESSION TYPE, COPPER, BLACKBURN TYPE CF2020 OR EQUAL
xx	4	1/2"x2" EXPANSION STUD ANCHOR, WITH ONE NUT AND WASHER
y	AS REQ'D	EQUIPMENT JOINT FILLER, URETHANE, SIKAFLEX 1A OR EQUAL,
ugp	3	CONDUCTOR TERMINAL, NEMA 2-HOLE PAD, ANDERSON TYPE L.
c	3	PLATED BRONZE BOLT, NUT, AND BELLEVILLE WASHER.
ic	2	INSULATING COVER, 600 VOLT



ONE LINE DIAGRAM

- NOTES:
1. UNIT INCLUDES INSTALLATION OF EQUIPMENT AND MATERIAL LISTED.
 2. PROVIDE SUFFICIENT SLACK IN PRIMARY NEUTRAL PIGTAIL AND CABLE TO PERMIT READY DISCONNECTION OF ELBOW AND MOUNTING ON PARKING STAND OR OPPOSITE BUSHING.
 3. UNIT INCLUDES TERMINATION OF NEW OR EXISTING SECONDARY SERVICE CONDUCTORS.
 4. UNIT INCLUDES STENCILLING SYSTEM STATION NUMBERS ON INTERIOR AND EXTERIOR OF ENCLOSURE.
 5. JOINT FILLER SHALL BE INSTALLED TO MAKE WATER TIGHT INSTALLATION.



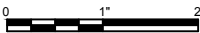
2	2-18	BROUGHT UP TO DATE
1	4-07	BROUGHT UP TO DATE
ISSUE	DATE	DESCRIPTION

PROJECT MANAGER B. HANSON	
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CHECKED BY	
PROJECT NUMBER	SOM-004

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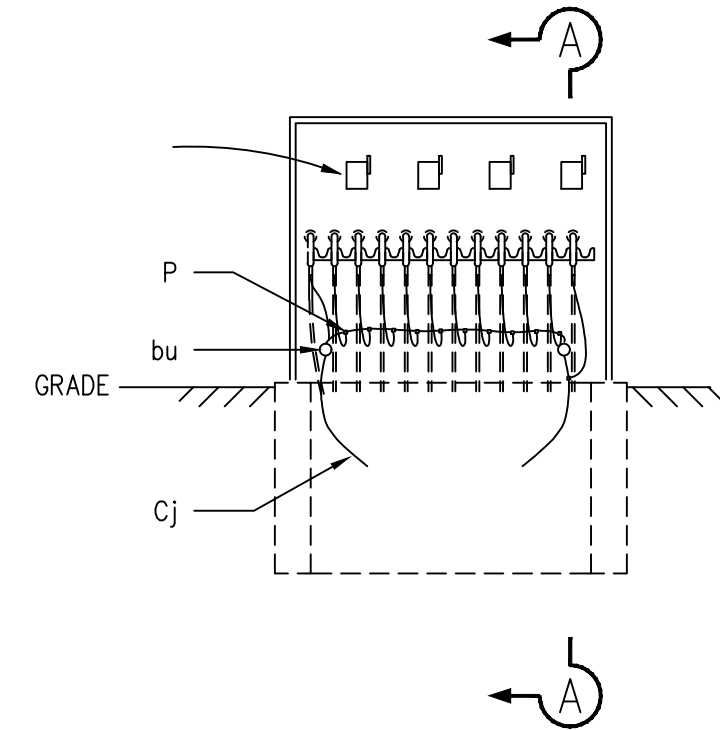
BOZEMAN, MONTANA

SINGLE PHASE TRANSFORMER

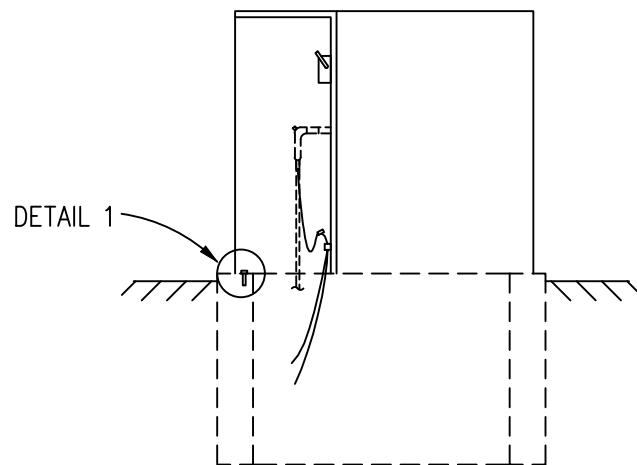


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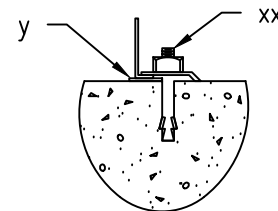
SHEET
IV-7



FRONT ELEVATION

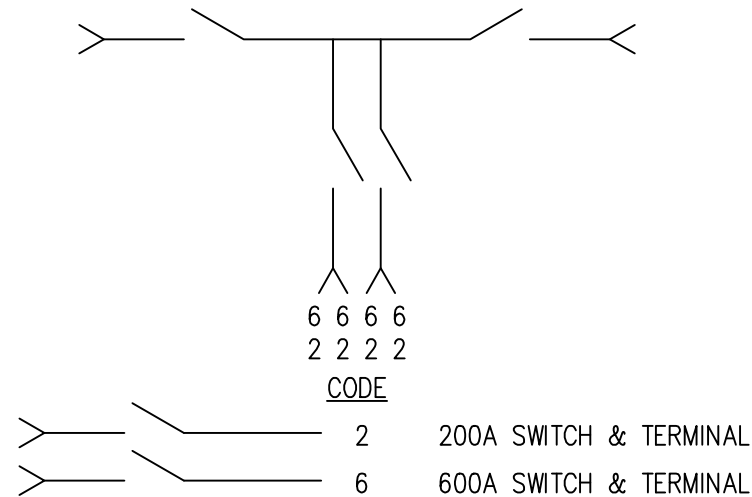


SECTION A-A



DETAIL 1

ITEM	NO.	MATERIAL
Ugn	1	SINGLE SIDED SWITCHGEAR, 3 PHASE
bu	2	CONNECTOR, EQUIPMENT GROUND, BLACKBURN TYPE TTC2P OR APPROVED EQUAL
Cj	AS REQ'D	GROUND WIRE, 1/0 STRANDED - CU.
P	AS REQ'D	CONNECTORS, COMPRESSION TYPE, COPPER, BLACKBURN TYPE CF2020 OR EQUAL
xx	4	1/2"x2" EXPANSION STUD ANCHOR, WITH ONE NUT AND WASHER
y	AS REQ'D	EQUIPMENT JOINT FILLER, URETHANE, SIKAFLEX 1A OR EQUAL



ONE LINE DIAGRAM

- NOTES:
1. UNIT INCLUDES INSTALLATION OF EQUIPMENT AND MATERIAL LISTED.
 2. PROVIDE SUFFICIENT SLACK IN PRIMARY NEUTRAL PIGTAIL AND CABLE TO PERMIT READY DISCONNECTION OF ELBOW AND MOUNTING ON PARKING STAND OR OPPOSITE BUSHING.
 3. UNIT INCLUDES STENCILLING SYSTEM STATION NUMBERS ON INTERIOR AND EXTERIOR OF ENCLOSURE.
 4. JOINT FILLER SHALL BE INSTALLED TO MAKE WATER TIGHT INSTALLATION.

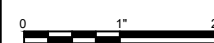


PROJECT MANAGER B. HANSON			DESIGNED BY	
			DRAWN BY	
			CHECKED BY	
2	2-18	BROUGHT UP TO DATE		
1	4-07	BROUGHT UP TO DATE		
ISSUE	DATE	DESCRIPTION	PROJECT NUMBER	SOM-004

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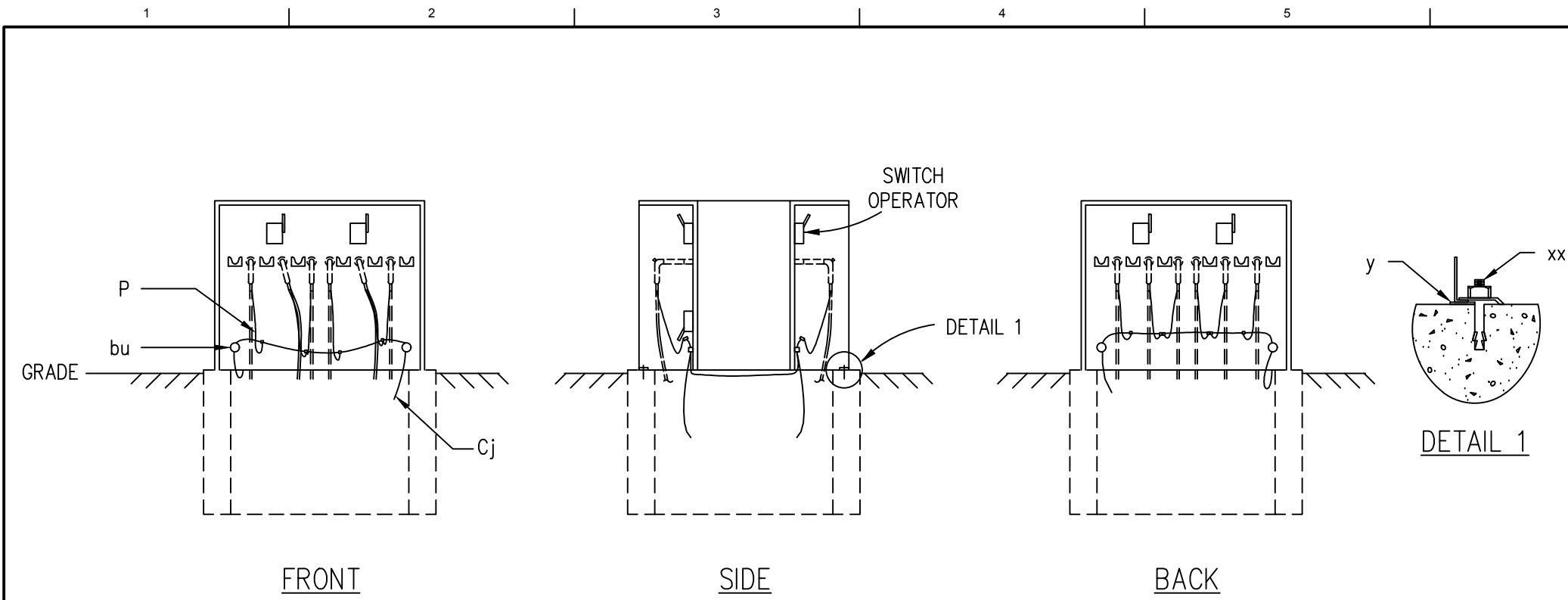
BOZEMAN, MONTANA

SWITCHGEAR - SINGLE SIDED



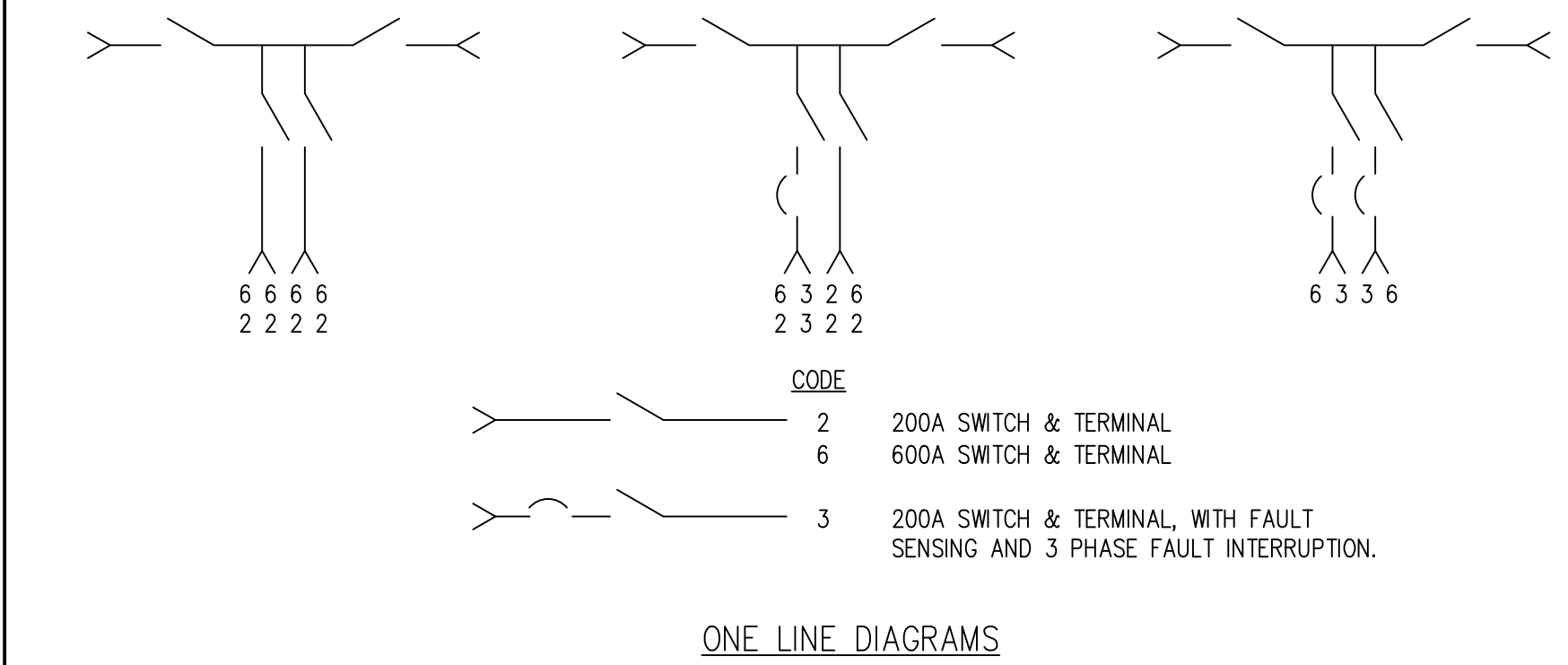
FILENAME UMSS.dwg
SCALE NONE

SHEET
IV-8



ITEM	NO.	MATERIAL
Ugn	1	SWITCHGEAR, DOUBLE SIDED, 3 PHASE
bu	4	CONNECTOR, EQUIPMENT GROUND,
		BLACKBURN TYPE TTC2P OR APPROVED EQUAL
Cj	AS REQ'D	GROUND WIRE, 1/0 STRANDED - CU.
P	AS REQ'D	CONNECTORS, COMPRESSION TYPE, COPPER,
		BLACKBURN TYPE CF2020 OR EQUAL
xx	4	1/2"x2" EXPANSION STUD ANCHOR, WITH ONE
		NUT AND WASHER
y	AS REQ'D	EQUIPMENT JOINT FILLER, URETHANE,
		SIKAFLEX 1A OR EQUAL,

- NOTES:
1. UNIT INCLUDES INSTALLATION OF EQUIPMENT AND MATERIAL LISTED.
 2. PROVIDE SUFFICIENT SLACK IN PRIMARY NEUTRAL PIGTAIL AND CABLE TO PERMIT READY DISCONNECTION OF ELBOW AND MOUNTING ON PARKING STAND OR OPPOSITE BUSHING.
 3. UNIT INCLUDES STENCILLING SYSTEM STATION NUMBERS ON INTERIOR AND EXTERIOR OF ENCLOSURE.
 4. JOINT FILLER SHALL BE INSTALLED TO MAKE WATER TIGHT INSTALLATION.



PROJECT MANAGER B. HANSON			DESIGNED BY	
			DRAWN BY	
			CHECKED BY	
2	2-18	BROUGHT UP TO DATE		
1	4-07	BROUGHT UP TO DATE		
ISSUE	DATE	DESCRIPTION	PROJECT NUMBER	SOM-004

MONTANA STATE UNIVERSITY

BOZEMAN, MONTANA

SWITCHGEAR - DOUBLE SIDED

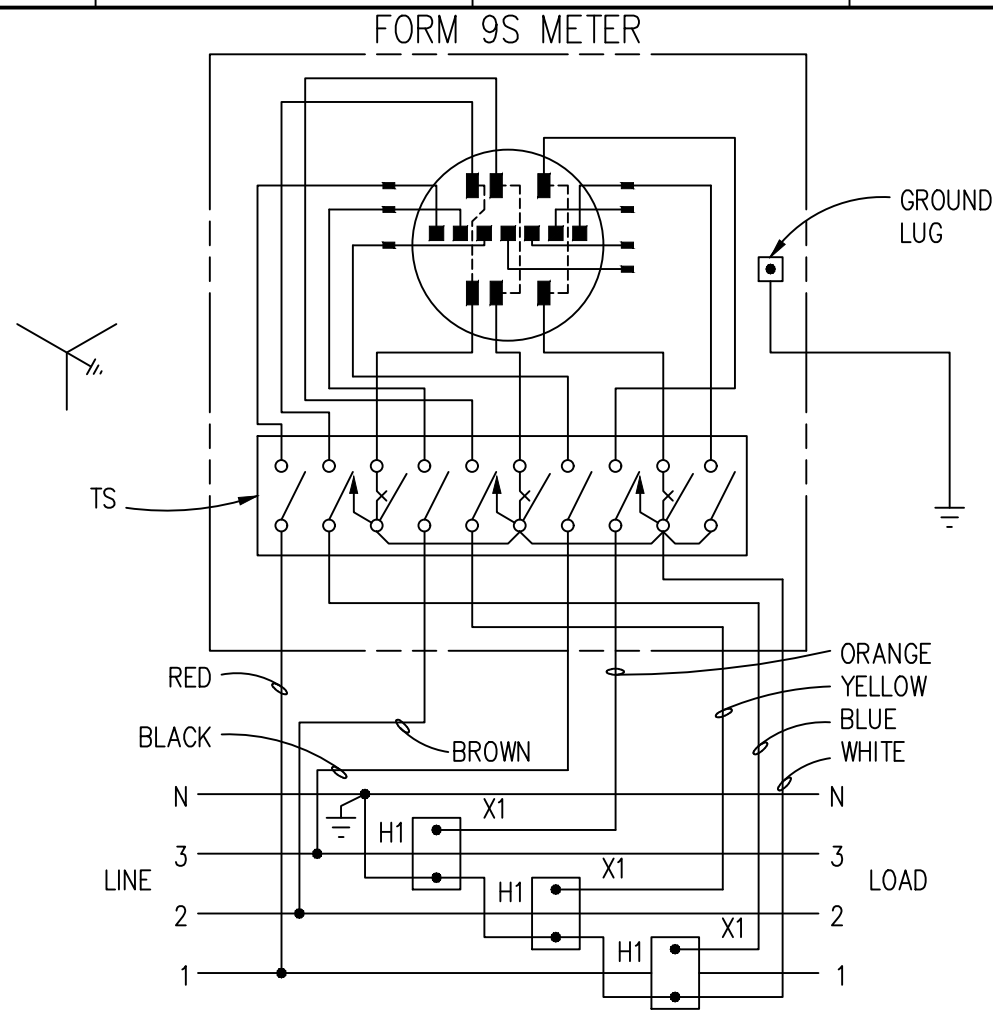
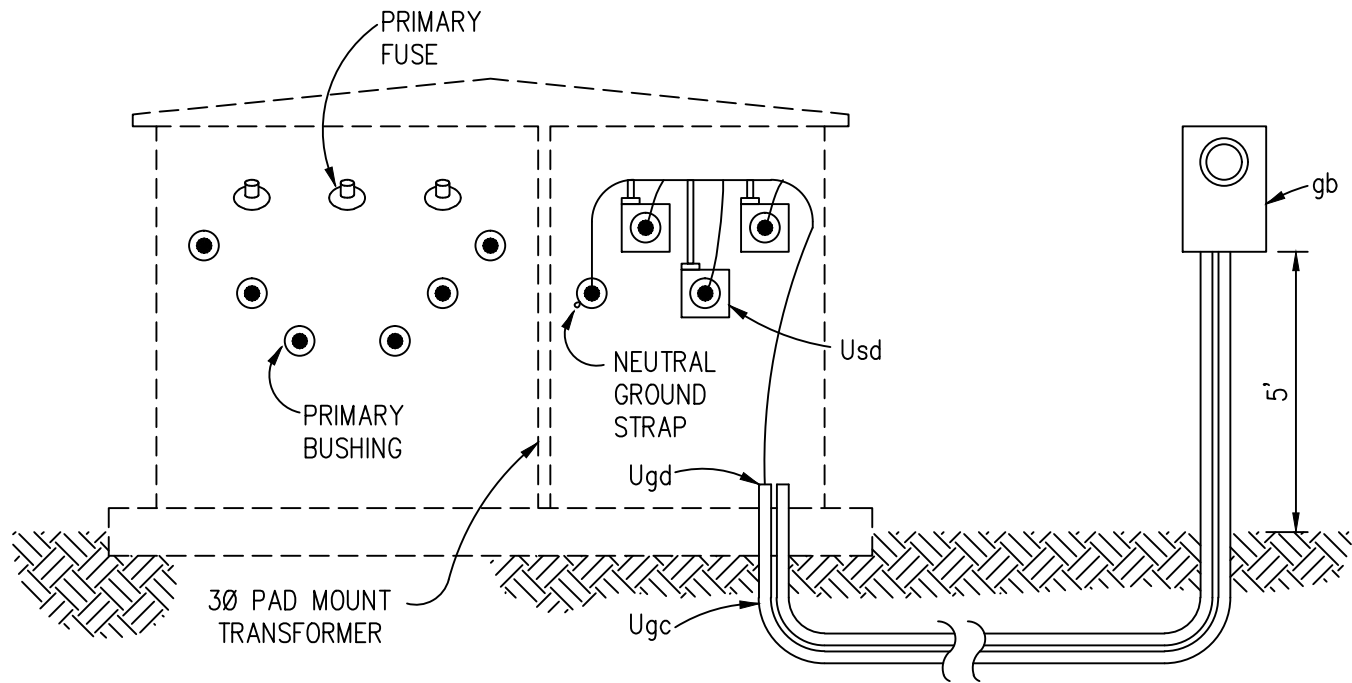
01"2"

FILENAME UMS.dwg

SCALE NONE

SHEET

IV-9



ITEM	NO.	MATERIAL
Usc	3	CURRENT TRANSFORMERS, WINDOW TYPE
		GE TYPE JAB-0 OR APPROVED EQUAL
		CT RATIO AS REQUIRED
av	AS REQ'D	#12 STR. CU. TW WIRE-COLOR AS NOTED
gb	1	13 TERMINAL METER SOCKET FOR FORM 9S
		METER, WITH CIRCUIT CLOSING DEVICE
Ugd	2	PROTECTIVE BUSHING
TS	1	10 POLE TEST SWITCH (PCC-PCC-PCC-N)
Ugc	AS REQ'D	CONDUIT PER NESC

NOTE:
1. UNIT INCLUDES INSTALLATION OF EQUIPMENT AND MATERIAL LISTED.



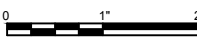
2	2-18	BROUGHT UP TO DATE
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PROJECT NUMBER	SOM-004

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BOZEMAN, MONTANA

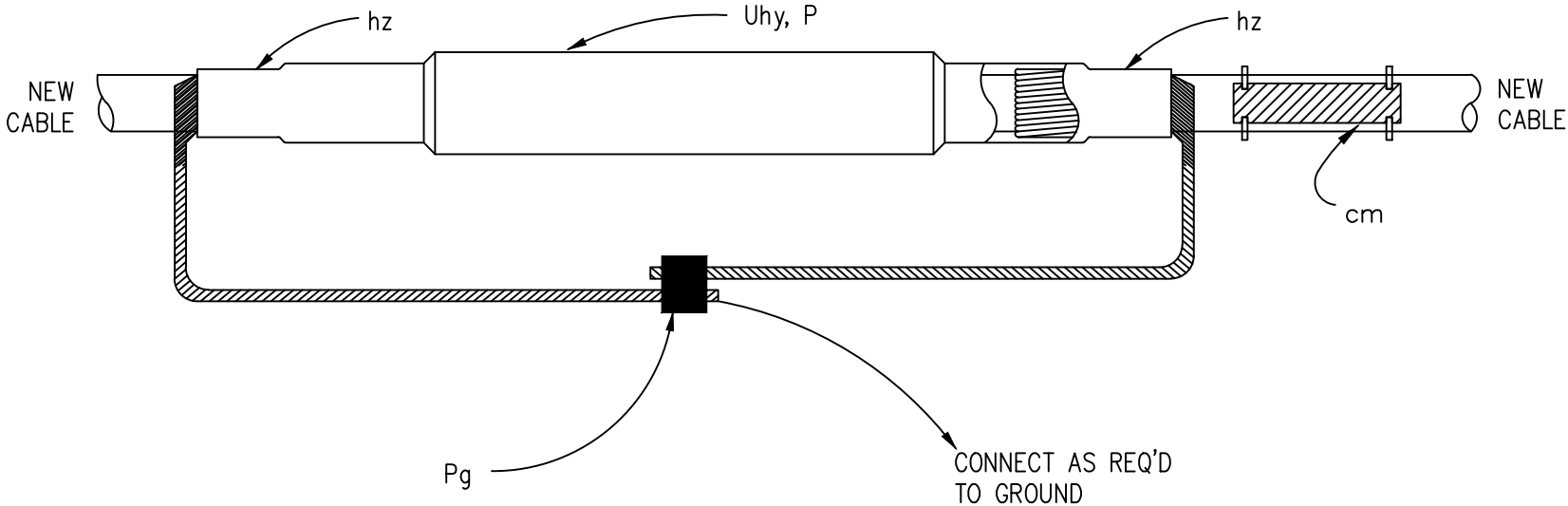
THREE PHASE METER INSTALLATION



FILENAME UM8.dwg
SCALE NONE

SHEET
IV-10

						ITEMDESCRIPTIONQUANTITY		
						Uhy	15KV CLASS SPLICE KIT, 1 PIECE MOLDED, COOPER POWER SYSTEMS EZ II OR APPROVED EQUAL	1
						cm	CABLE MARKER, RELIABLE TYPE S-850	1
						hz	SEALING KIT, 3M TYPE 8452 OR EQUAL	2
						Pg	COMPRESSION CONNECTOR, BLACKBURN TYPE CF2020 OR EQUAL.	1
						P	COMPRESSION SPLICE	SUPPLIED BY KIT MFGR.



- NOTES
1. UNIT INCLUDES INSTALLATION OF EQUIPMENT AND MATERIAL LISTED.
 2. INSTALLATION OF CABLE SPLICES SHALL BE IN ACCORDANCE WITH MANUFACTURES INSTRUCTIONS.
 3. GROUND SPLICE SURFACE IN ACCORDANCE WITH MANUFACTURERS INSTRUCTIONS.
 4. SPLICE SHALL BE INSTALLED ONLY WHERE SHOWN ON THE PLANS.
 5. SPLICE CURRENT RATING SHALL BE EQUAL TO CABLE AMPACITY.

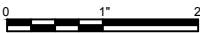


			PROJECT MANAGER B. HANSON	
			DESIGNED BY	
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			CHECKED BY	
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ISSUE	DATE	DESCRIPTION	PROJECT NUMBER	SOM-004

MONTANA STATE UNIVERSITY

BOZEMAN, MONTANA

PRIMARY CABLE SPLICE

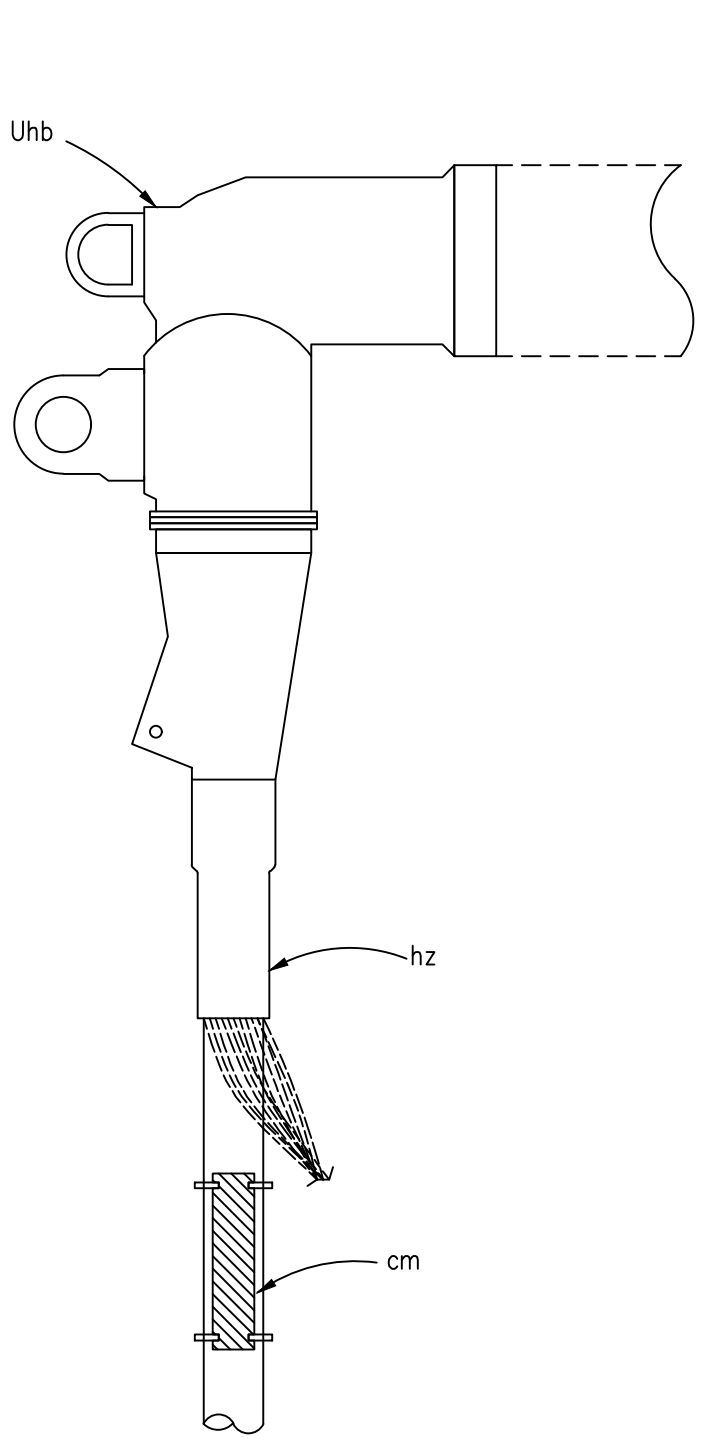


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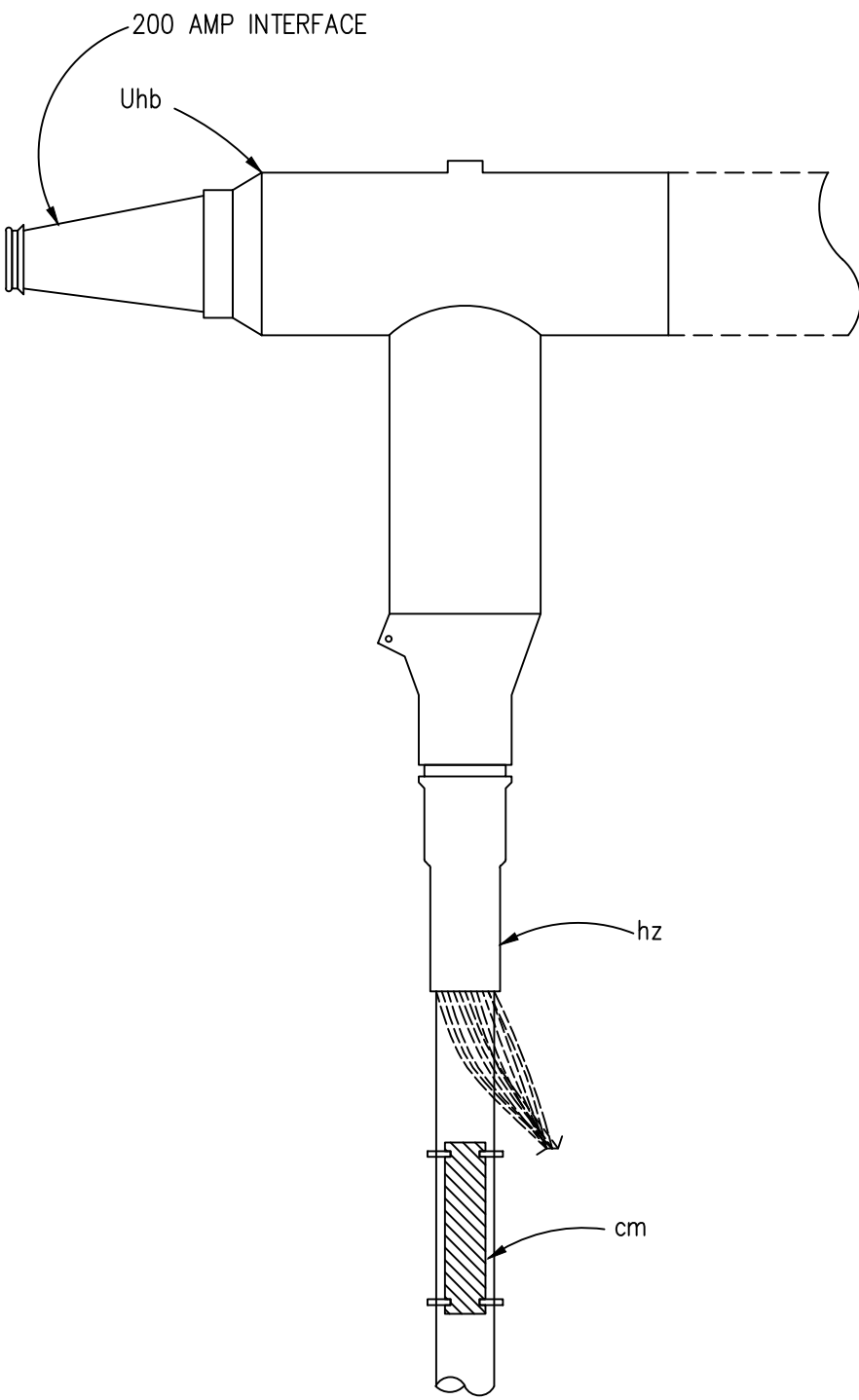
SHEET
IV-12

12345678

200 AMP LOADBREAK



600 AMP DEADBREAK



ITEM	DESCRIPTION	QUANTITY	
		200AMP	600AMP
Uhb	15KV CLASS 200A, LOADBREAK ELBOW CONNECTOR, WITH TEST POINT, COOPER OR APPROVED EQUAL.	1	
Uhb	15KV CLASS 600A, DEADBREAK ELBOW CONNECTOR, WITH REMOVABLE 200 AMP INTERFACE, COOPER T-OP ii OR APPROVED EQUAL.		1
hz	SEALING KIT, 3M TYPE 8452 OR APPROVED EQUAL	1	1
Cm	CABLE MARKER, RELIABLE TYPE S-850	1	1

NOTES

1. UNIT INCLUDES INSTALLATION OF EQUIPMENT AND MATERIAL LISTED.
2. INSTALLATION OF CABLE ELBOWS SHALL BE IN ACCORDANCE WITH MANUFACTURES INSTRUCTIONS.
3. GROUND ELBOW SURFACE IN ACCORDANCE WITH MANUFACTURERS INSTRUCTIONS.



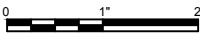
2	2-18	BROUGHT UP TO DATE
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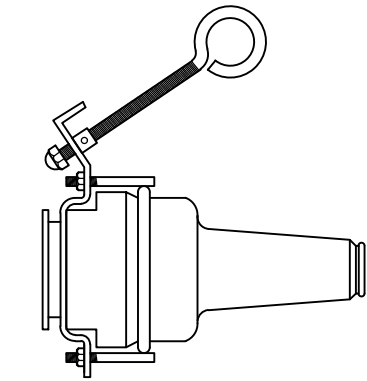
BOZEMAN, MONTANA

ELBOW CONNECTORS

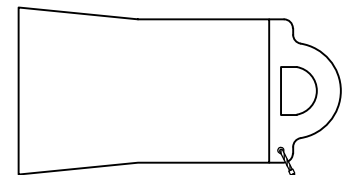


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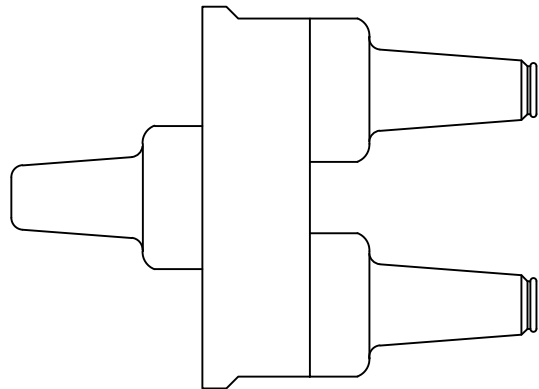


UM6-15 200 AMP
UM6-16 600 AMP



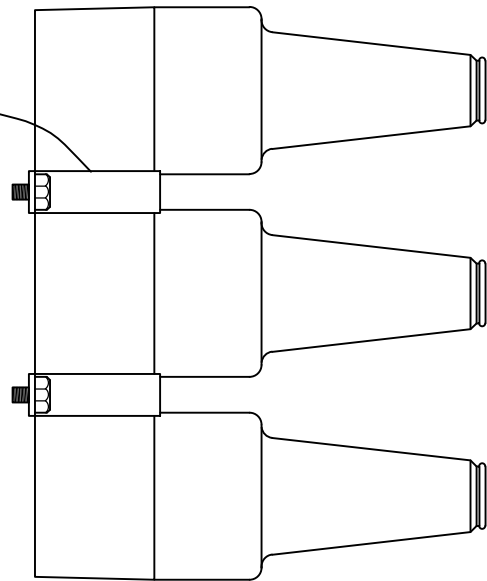
UM6-10 200 AMP
UM6-11 600 AMP

CONNECT TO
GROUND AS
REQ'D



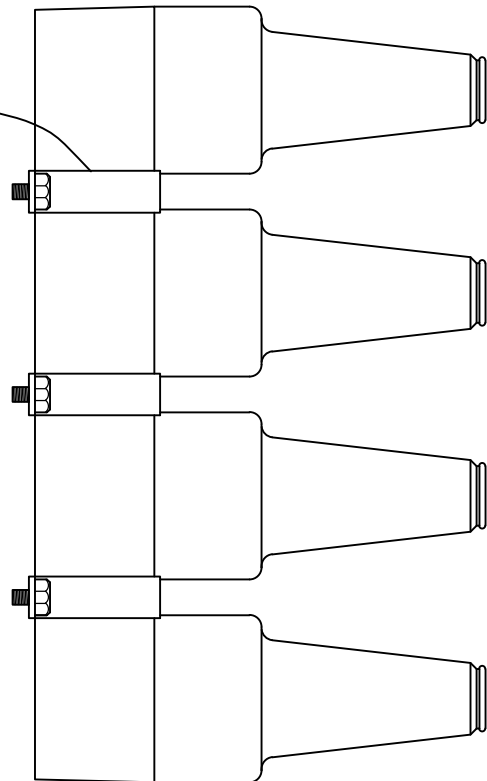
UM6-5

U-STRAP
AS REQ'D



UM6-21

U-STRAP
AS REQ'D



UM6-22

ITEM	DESCRIPTION
UM6-15	15KV CLASS, 200 AMP INTERFACE, STANDOFF SINGLE POINT TERMINATION BUSHING WITH STANDARD BRACKET. COOPER OR APPROVED EQUAL.
UM6-5	15KV CLASS, LOADBREAK TWO POINT 200A BUSHING INSERT, COOPER OR APPROVED EQUAL.
UM6-21	15KV CLASS, LOADBREAK 200A THREE POINT TERMINATION BUSHING WITH U-STRAPS, COOPER OR APPROVED EQUAL.
UM6-22	15KV CLASS, LOADBREAK 200A FOUR POINT TERMINATION BUSHING WITH U-STRAPS COOPER OR APPROVED EQUAL.
UM6-10	15KV CLASS, INSULATED PROTECTIVE CAP, 200A INTERFACE, COOPER OR APPROVED EQUAL.
UM6-11	15KV CLASS, INSULATED PROTECTIVE CAP, 600 AMP INTERFACE, COOPER OR APPROVED EQUAL.
UM6-16	15KV CLASS, 600 AMP INTERFACE, INSULATED STAND OFF BUSHING WITH T-OP II STUD, COOPER OR APPROVED EQUAL.



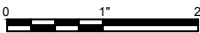
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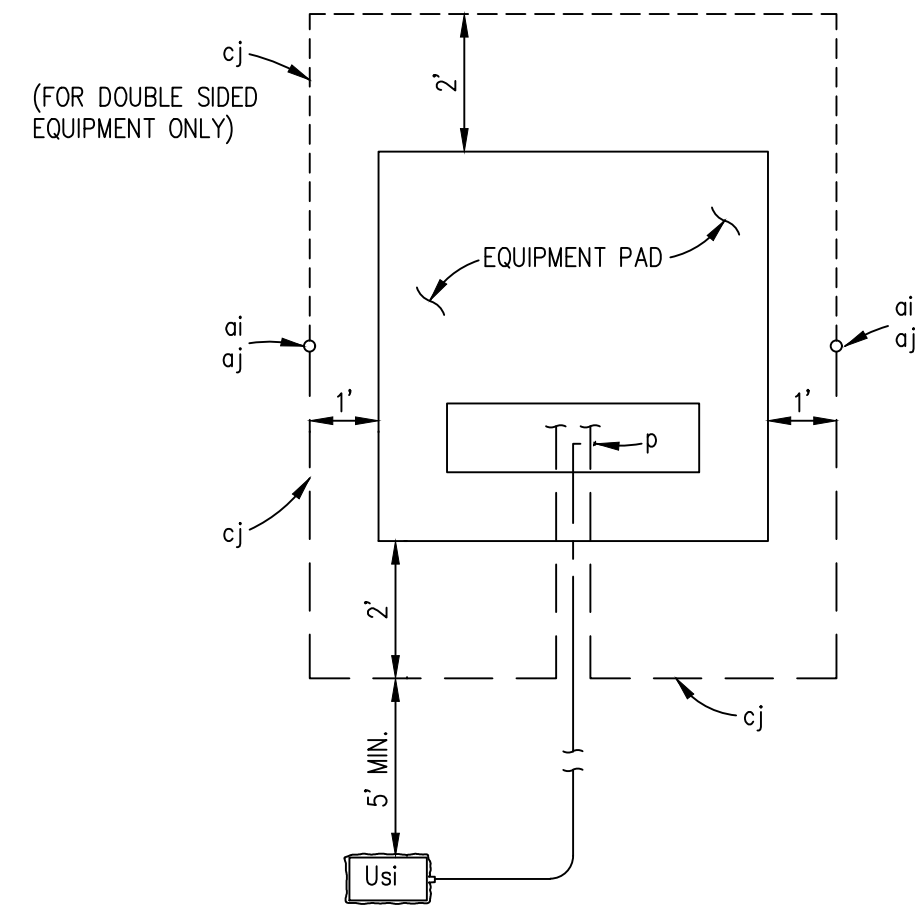
BOZEMAN, MONTANA

LOAD BREAK TERMINATION
BUSHINGS AND CAPS

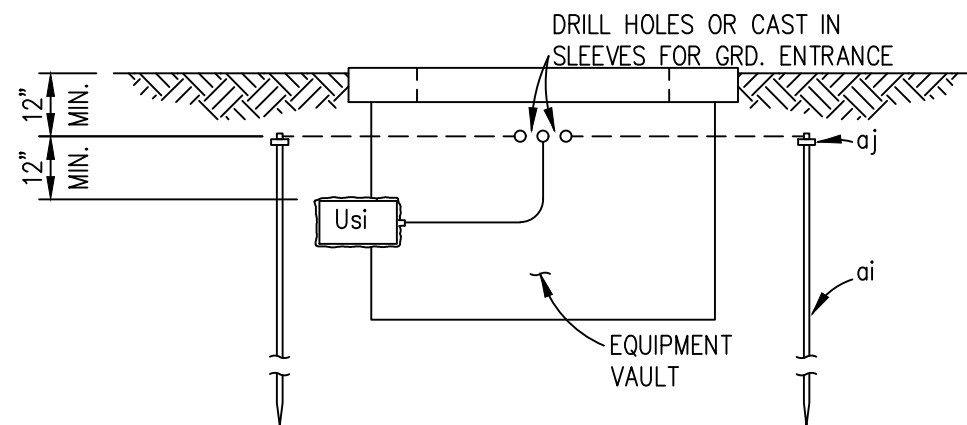


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SHEET	IV-14
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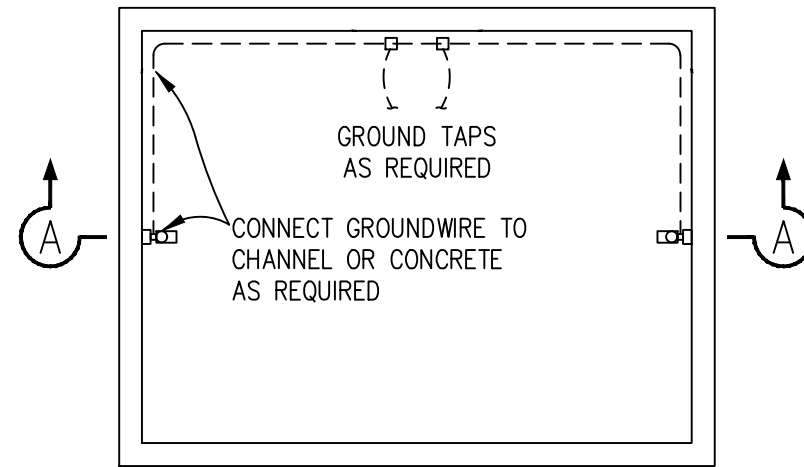


PLAN

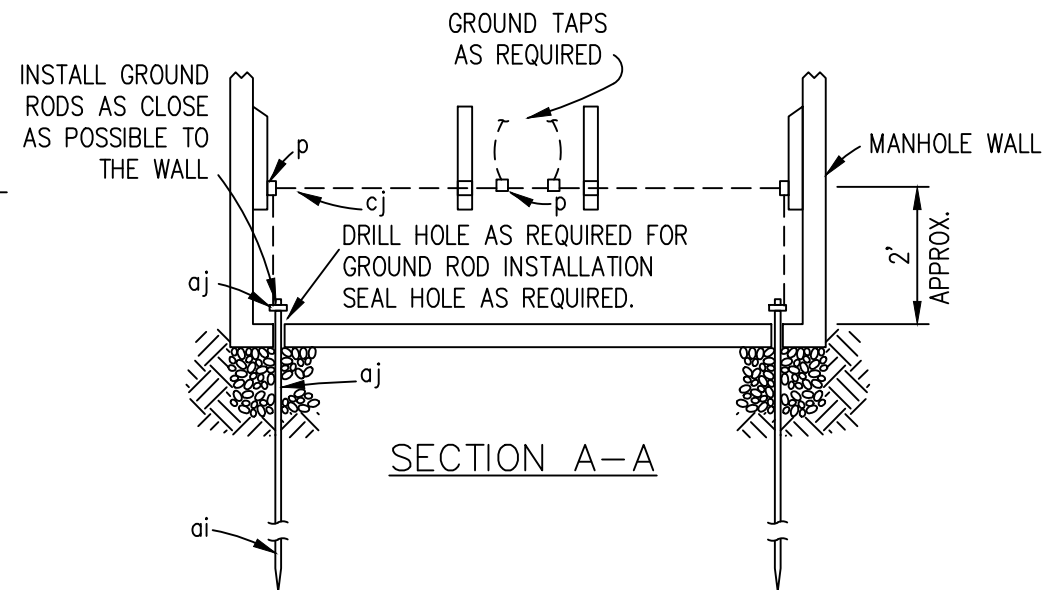


FRONT

EQUIPMENT GROUND



PLAN



SECTION A-A

MANHOLE GROUND

ITEM	DESCRIPTION	EQUIPMENT GROUND	MANHOLE GROUND
ai	GROUND ROD 3/4" x 10' COPPERCLAD.	2	2
aj	CLAMP, BLACKBURN TYPE GUV OR EQUAL	2	2
cj	1/0 STR. COPPER GROUND WIRE	AS REQ'D	AS REQ'D
p	CONNECTORS, COMPRESSION BLACKBURN TYPE CF2020 OR EQUAL.	AS REQ'D	AS REQ'D
Usi	MAGNESIUM ANODE, 5LB. SACRIFICIAL WITH INSULATED LEAD	1	

NOTES

- UNIT INCLUDES INSTALLATION OF EQUIPMENT AND MATERIAL LISTED.



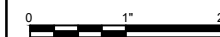
ISSUE	DATE	DESCRIPTION
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PROJECT MANAGER	B. HANSON
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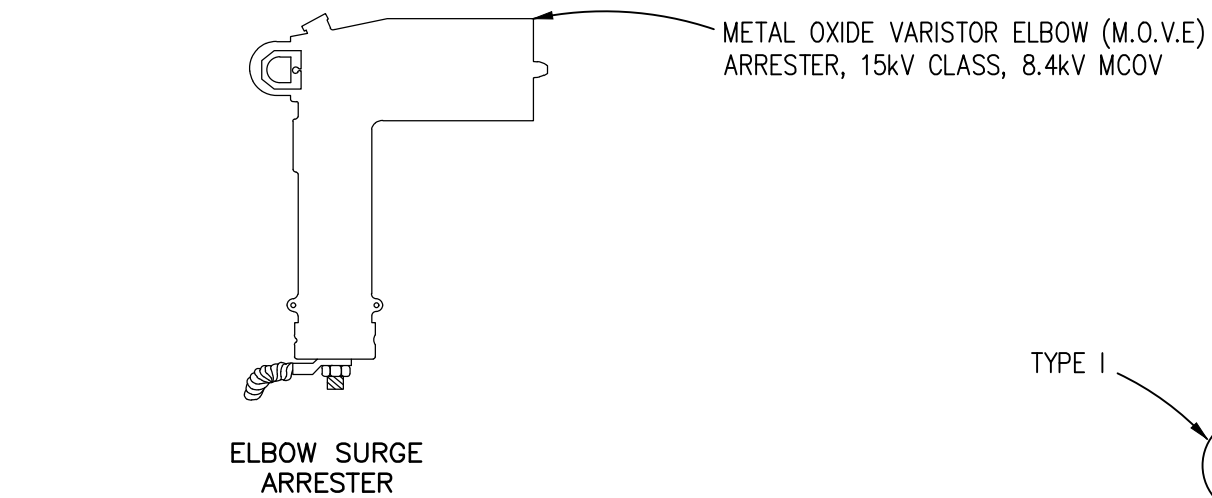
BOZEMAN, MONTANA

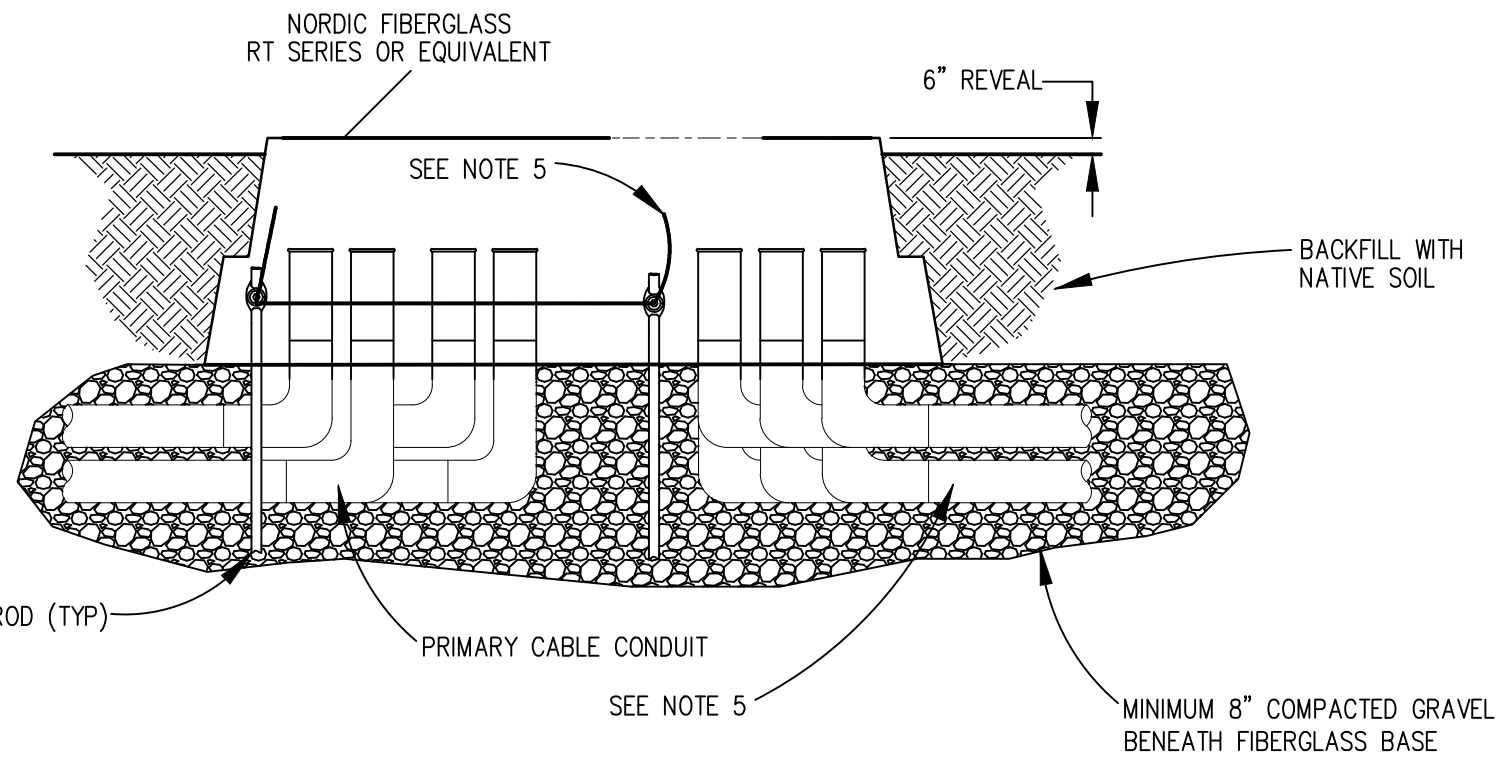
GROUNDING ASSEMBLIES



FILENAME UM2_16.dwg
SCALE NONE

SHEET
IV-15





- NOTES:
- 1. ALL DISTURBED EARTH AND COMPACTED GRAVEL SHALL BE COMPACTED TO A MINIMUM OF 90% MAXIMUM DRY DENSITY AS DETERMINED BY THE MODIFIED PROCTOR TEST.
 - 2. CRUSHED ROCK AND COMPACTED GRAVEL SHALL MEET GRADATION REQUIREMENTS AS DESCRIBED IN THE WRITTEN SPECIFICATIONS.
 - 3. FIBERGLASS BOX TO BE MINIMUM 36" DEEP.
 - 4. CONTRACTOR TO DETERMINE PAD DIMENSIONS BASED ON TRANSFORMER SIZING.
 - 5. CONNECT GROUND TO GROUNDING LUG SUPPLIED ON TRANSFORMER



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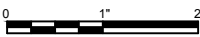
PROJECT MANAGER B. HANSON	
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PROJECT NUMBER	SOM-004

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BOZEMAN, MONTANA

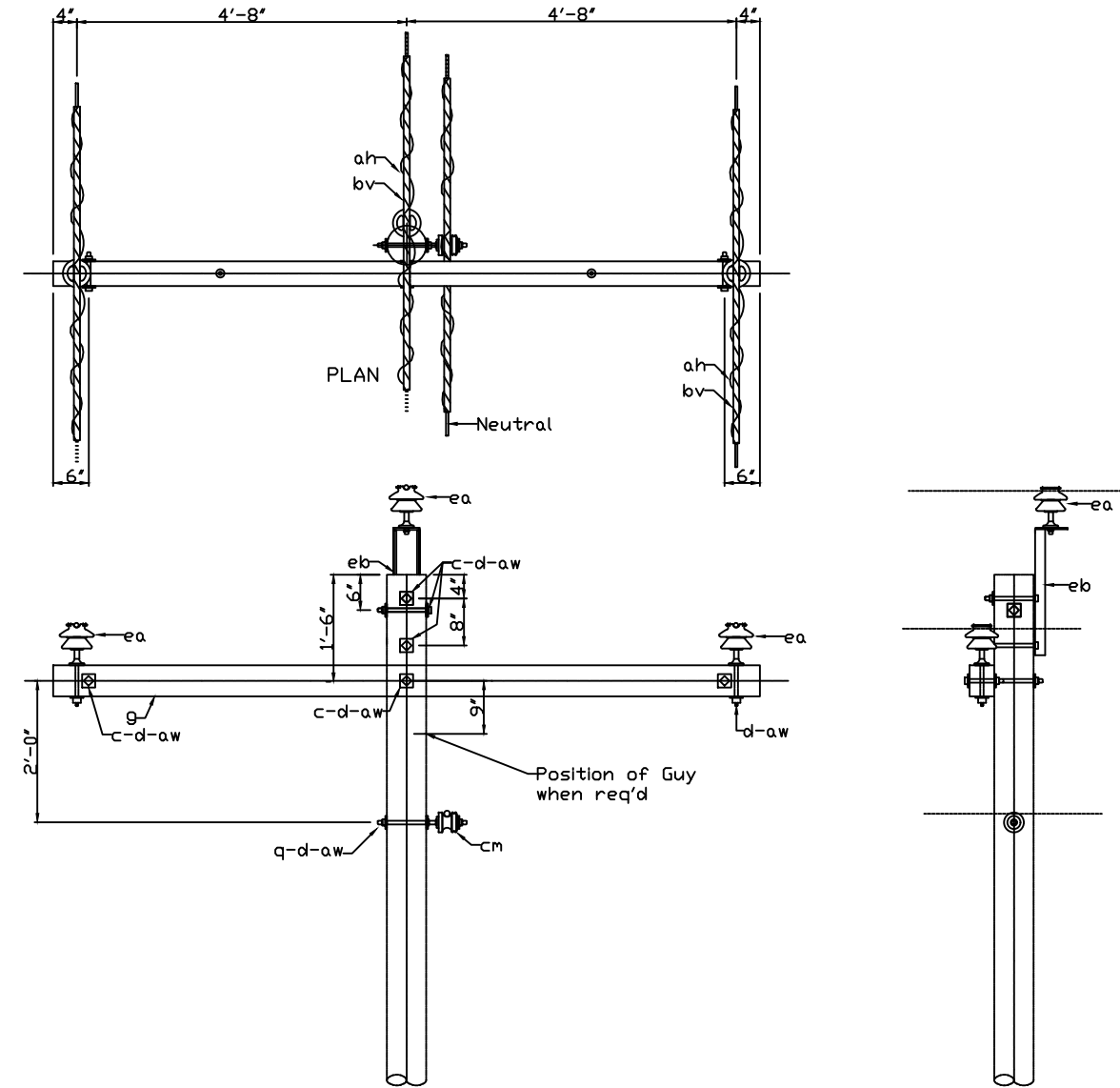
THREE PHASE TRANSFORMER

FIBERGLASS PEDESTAL

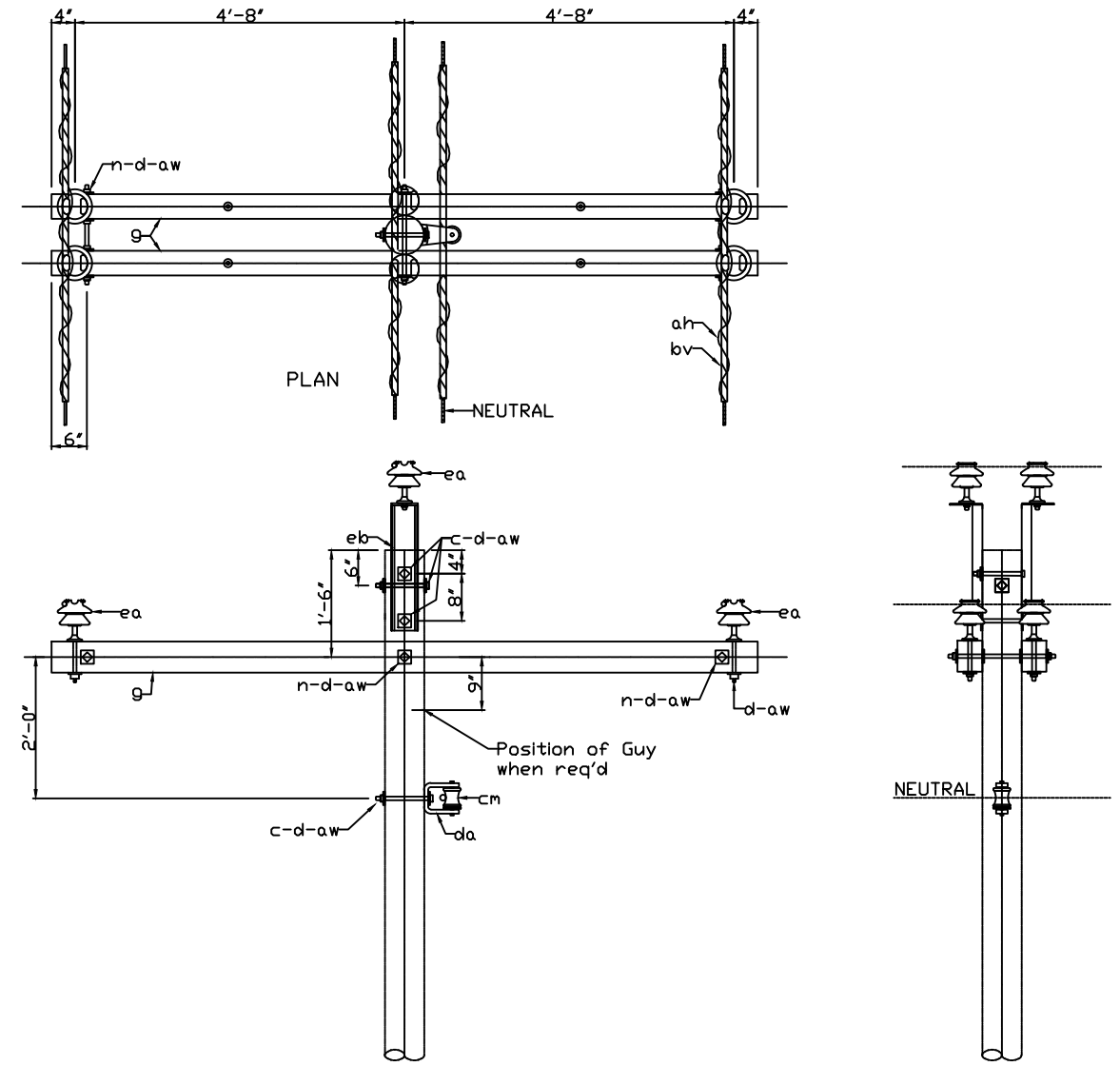


FILENAME	UM1_5FG.dwg
SCALE	NONE

SHEET	IV-17
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ID	QTY	MATERIAL DESCRIPTION	ID	QTY	MATERIAL DESCRIPTION
c	6	BOLTS, MACHINE 5/8 X 6-12	d	10	WASHER, SQUARE, 5/8" 2 1/4" X 2 1/4" FLAT
c	1	BOLTS, MACHINE 5/8 X 14-24			#4 ACSR
q	1	BOLT, DOUBLE UPSET	bv	4	RODS, ARMOR #4
g	1	CROSSARMS, 10	ah	3	TIES, #4
cm	1	INSULATOR, SPOOL	ah	1	TIES, #4
ea	3	INSULATOR, PIN TYPE			
aw	9	WASHERS, SPRING 5/8"			
eb	1	BRACKET, POLE TOP, RIDGE IRON			
ea	2	PIN INSULATOR STUD-LONG			
ea	1	PIN INSULATOR STUD-SHORT			
d	2	WASHER, SQUARE, 1/2" 2" X 2" FLAT			
DESIGN PARAMETERS MAX TRANSVERSE LOAD: 750 LBS. PER CONDUCTOR MAX LINE ANGLE WITHIN LOAD LIMITS: 2°			SINGLE SUPPORT ON CROSSARM TANGENT 3Ø PRIMARY - 12.47/7.2 kV		
			C1.11		



ID	QTY	MATERIAL DESCRIPTION	ID	QTY	MATERIAL DESCRIPTION
c	4	BOLTS, MACHINE 5/8 X 6-12	ea	4	PIN INSULATOR STUD-LONG
n	3	BOLTS, D.A. 5/8 X 14-26	ea	2	PIN INSULATOR STUD-SHORT
da	1	BRACKET ANGLE, NEUTRAL			#4 ACSR
g	2	CROSSARMS, 10	bv	4	RODS, ARMOR #4
cm	1	INSULATOR, SPOOL	ah	3	TIES, #4
ea	6	INSULATOR, PIN TYPE	ah	1	TIES, #4
aw	13	WASHERS, SPRING 5/8"			
d	20	WASHERS, SQUARE, 5/8" 2 1/4" x 2 1/4" FLAT			
ek	14	LOCKNUT, 5/8" CONCAVE SQUARE			
ek	4	LOCKNUT, 1/2" CONCAVE SQUARE			
eb	2	BRACKET, POLE TOP, RIDGE IRON			
DESIGN PARAMETERS MAX LINE ANGLE WITHIN LOAD LIMITS: 2°-16°			DOUBLE SUPPORT ON CROSSARM 3Ø PRIMARY - 12.47/7.2 kV		
			C2.21		



PROJECT MANAGER B. HANSON			DESIGNED BY	
			DRAWN BY	
			CHECKED BY	
2	7-18	BROUGHT UP TO DATE		
1	4-07	BROUGHT UP TO DATE		
ISSUE	DATE	DESCRIPTION	PROJECT NUMBER	SOM-004

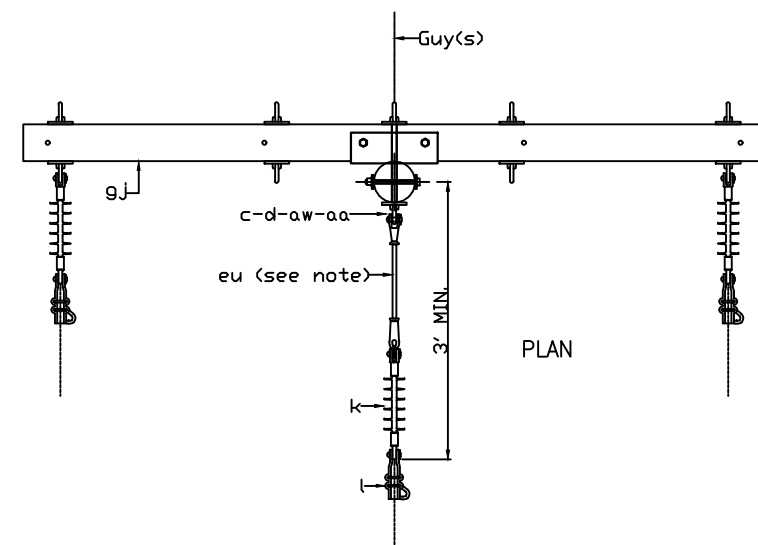
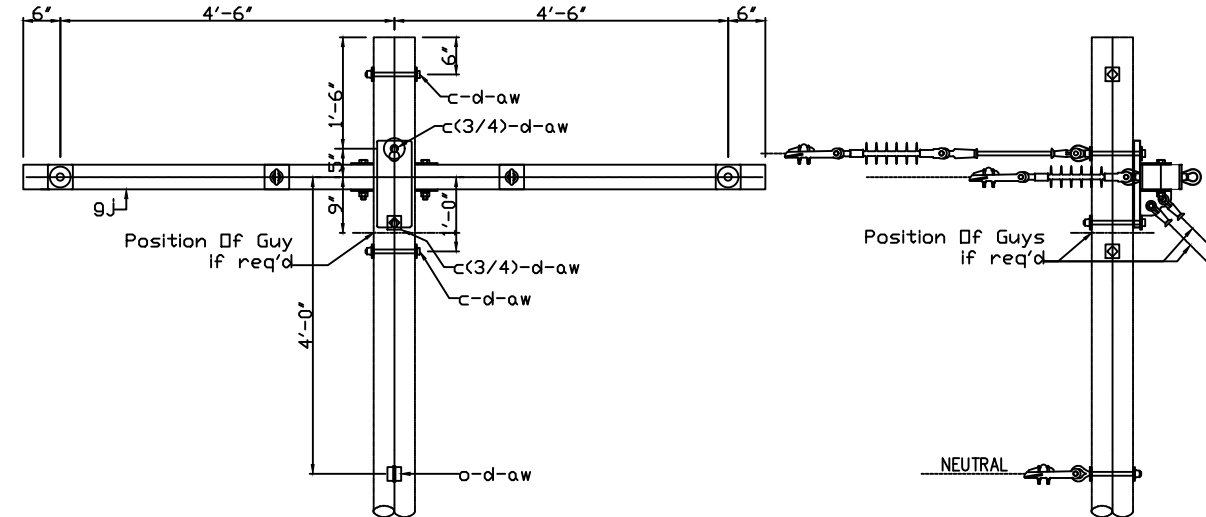
MONTANA STATE UNIVERSITY

BOZEMAN, MONTANA

TANGENT POLE TOP ASSEMBLY
ANGLE POLE TOP ASSEMBLY

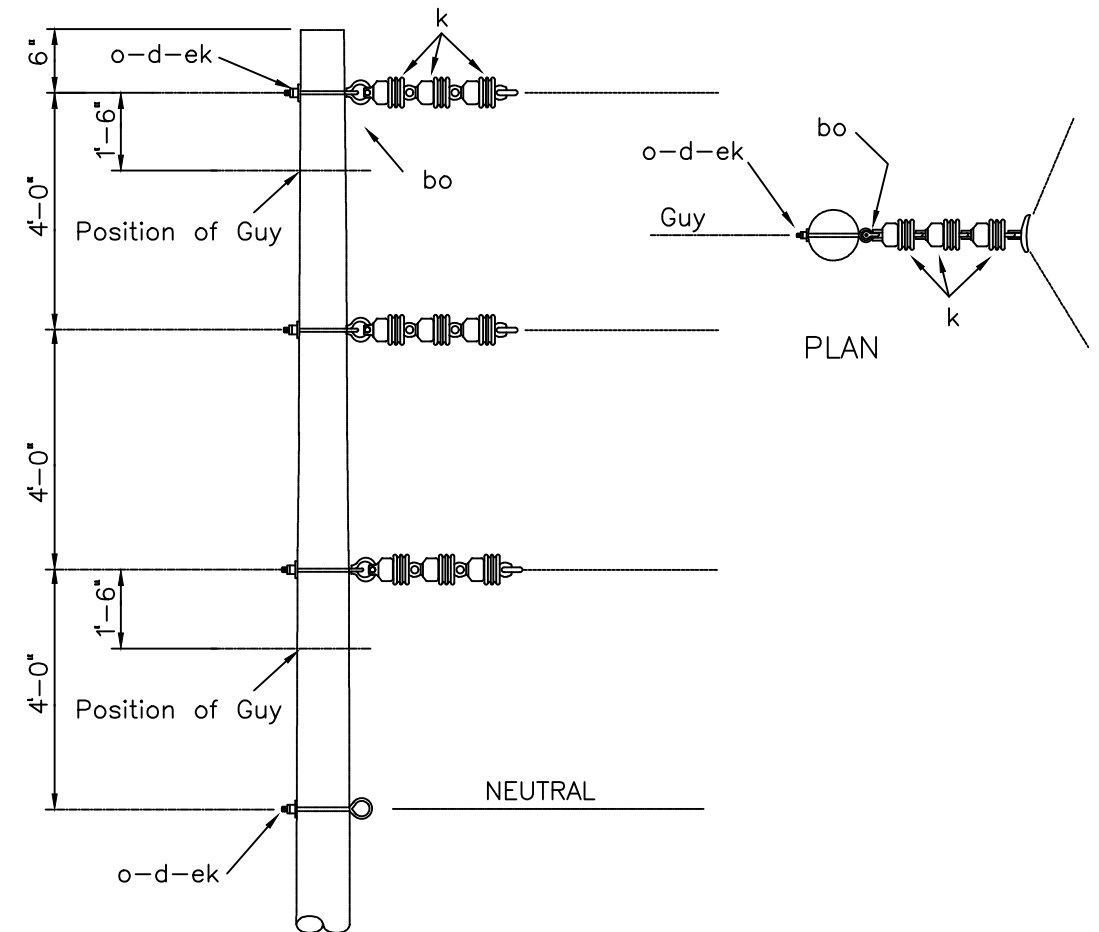
0 1" 2" FILENAME VC1_2.dwg
SCALE NONE

SHEET
IV-19



ID	QTY	MATERIAL DESCRIPTION
gj	1	10 FT, FIBERGLASS, DEADEND ASSEMBLY
k	3	12.47KV DEADEND INSULATOR
l	4	DEADEND CLAMP (#4 ACSR)
o	1	OVALEYE 3/4" X 12" BOLT
c	2	SQUARE HEAD 3/4" X 12" MACHINE BOLT
c	2	SQUARE HEAD 5/8" X 10" MACHINE BOLT
ow	2	3/4" SPRING WASHER
aw	3	5/8" SPRING WASHER
d	2	3" X 3" X 1/4" CURVED SQUARE WASHER (3/4")
d	6	2 1/4" X 2 1/4" X 3/16" CURVED SQUARE WASHER (5/8")

DESIGN PARAMETERS	SINGLE DEADEND ON CROSSARM ASSEMBLY
ALLOWABLE LONGITUDINAL LOAD EQUALS LESSER OF: 5,000 lbs/Conductor, or Manufacturer's Specifications	C5.31



ID	QTY	MATERIAL DESCRIPTION
d	4	WASHER, SQUARE, 3", CURVED
k	9	12.47KV DEADEND INSULATOR
o	4	DEADEND CLAMP (#4 ACSR)
bo	4	OVALEYE 3/4" X 12" BOLT
ek	4	SQUARE HEAD 3/4" X 12" MACHINE BOLT

DESIGN PARAMETERS	SUSPENSION ANGLE
ALLOWABLE TRANSVERSE LOAD: 5,000 LBS./CONDUCTOR 30° - 60°: SMALLER CONDUCTORS	3Ø PRIMARY - 12.47/7.2 kV
	C3.1

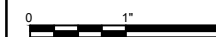


PROJECT MANAGER B. HANSON			DESIGNED BY	
			DRAWN BY	
			CHECKED BY	
2	7-18	BROUGHT UP TO DATE		
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ISSUE	DATE	DESCRIPTION	PROJECT NUMBER	SOM-004

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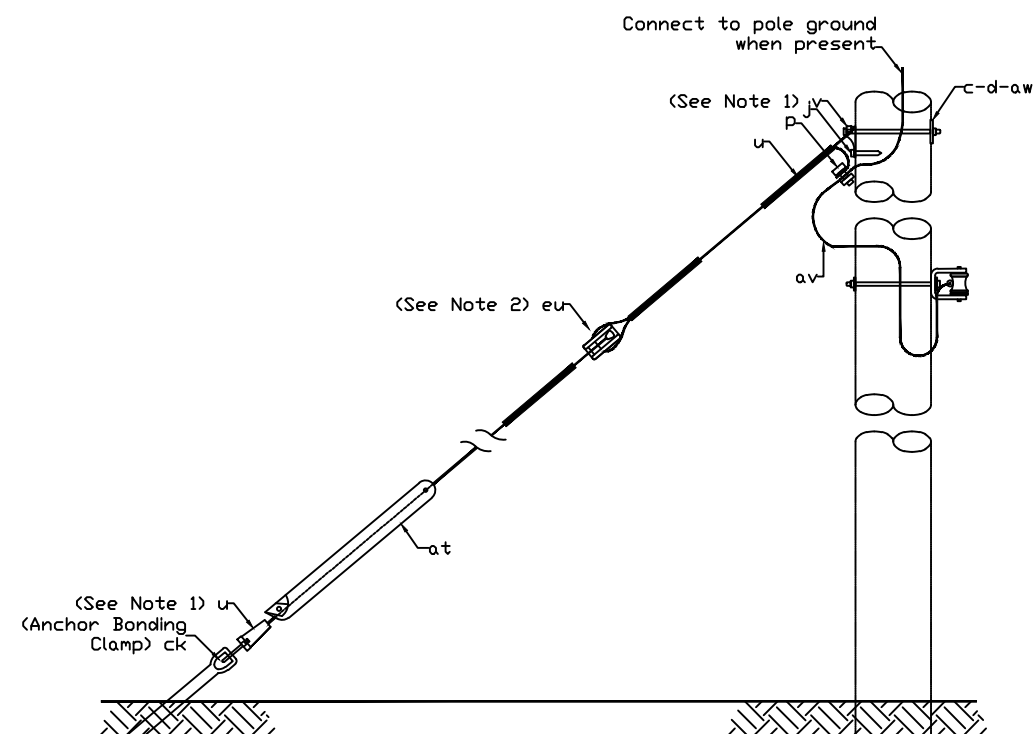
BOZEMAN, MONTANA

SUSPENSION ANGLE ASSEMBLY
DEADEND POLE TOP ASSEMBLY



FILENAME VC3_5-7.dwg
SCALE NONE

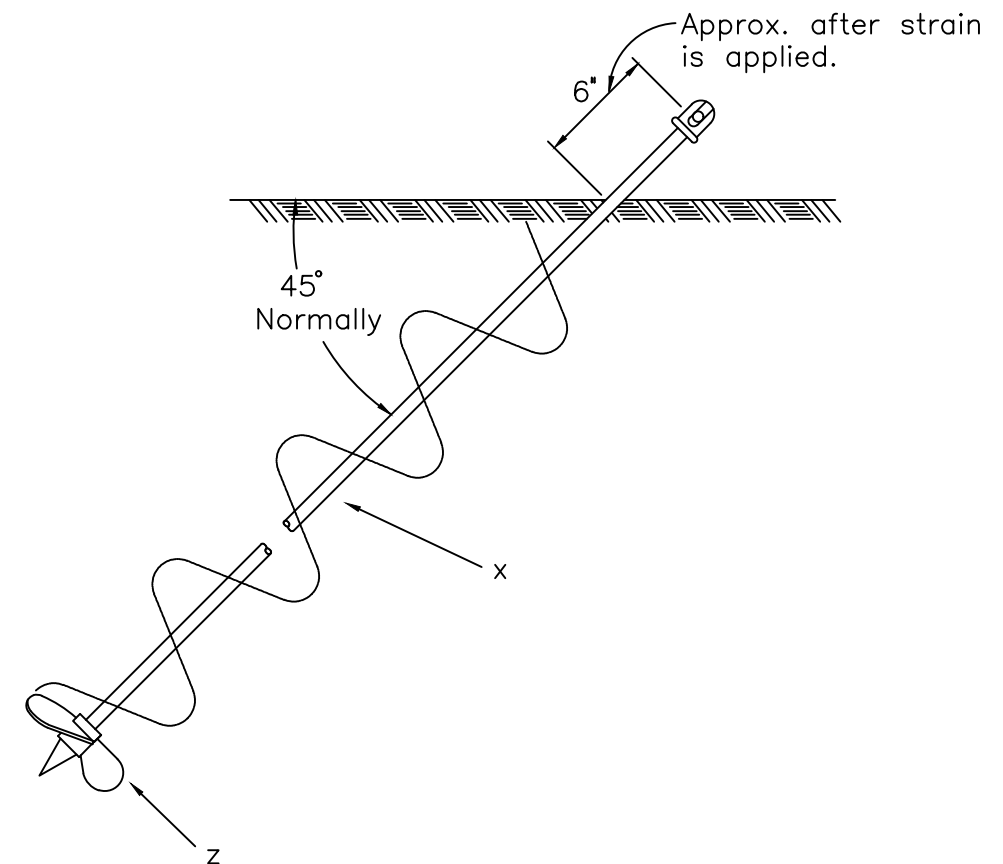
SHEET
IV-20



NOTES:

1. Other accepted and equivalent guy deadend (item "u") and attachment (item "v") material may be substituted for the ones shown.
2. Install "Johnny Ball" as required for cathodic protection. Bottom of "Johnny Ball" must be a minimum of 8' above groundline, per NESC Rule 279 A2.

ID	QTY	PART	MATERIAL DESCRIPTION	ID	QTY	PART	MATERIAL DESCRIPTION
p	1	15305	CONN H-TAP ALL SIZES	c	1	6351	BOLTS, MACHINE 3/4 X 6-12
p	1	15335	CONN CF #44, #22, #1010, 102-1, AS REQ'D	aw	1	96504	WASHERS, SPRING 3/4"
p	1	15340	CONNECTOR, R-12, K1	d	1	96506	WASHER, SQUARE, 3/4" 4"x4" CURVED
p	1	15342	CONNECTOR, ANCHOR ROD BONDING	av	6	97004	WIRE GROUND #4 COPPER BARE
v	1	2101	ATTACHMENT, GUY	y	45	97011	WIRE, GUY, 3/8 EHS
u	3	28001	GRIPS, GUY PREF				
u	1	28004	GRIP GUY 3 BOLT, & STRANDWISE				
at	1	28601	MARKER, GUY				
eu	1	34301	INSULATOR, GUY STRAIN				
j	1	6332	LAG, SCREW 1/2"x4"				
DESIGN PARAMETERS PERMITTED LOAD IS LEAST OF: 8,500 lbs.(in any direction) or 90% of RATED BREAKING STRENGTH OF GUY WIRE				SINGLE DOWN GUY-HEAVY DUTY (THROUGH BOLT TYPE)			
				E1.1			



NOTE: Designated maximum holding power rating assumes proper installation in class 5 soil.

ID	QTY	MATERIAL DESCRIPTION
x	1	RODS, ANCHOR, THIMBLE EYE, 5/8" X 7'
z	1	ANCHOR, SCREW TYPE, POWER INSTALLED

DESIGN PARAMETERS MAXIMUM HOLDING POWER = 8,000 LB	SCREW ANCHOR
	F2.8

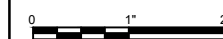


			PROJECT MANAGER	B. HANSON
			DESIGNED BY	
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			CHECKED BY	
2	7-18	BROUGHT UP TO DATE		
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ISSUE	DATE	DESCRIPTION	PROJECT NUMBER	SOM-004

MONTANA STATE UNIVERSITY

BOZEMAN, MONTANA

GUY ASSEMBLY
ANCHOR ASSEMBLY



FILENAME	E1-1_F2-8.dwg
SCALE	NONE

SHEET

IV-21

[illegible]

Montana State University																								
Stringing Table																								
Conductor #4 Swanate												Ruling Span: 350 Feet												
Prepared By: HDR Engineering, Inc.												NESC Medium Loading												
Stringing Chart: Initial Sags - Sag in inches, span in feet, degrees in Fahrenheit, return of wave in seconds																								
	20 Degrees				25 Degrees				30 Degrees				35 Degrees				40 Degrees				45 Degrees			
	Wave Return				Wave Return				Wave Return				Wave Return				Wave Return				Wave Return			
Span	Sag	3rd	5th		Sag	3rd	5th		Sag	3rd	5th		Sag	3rd	5th		Sag	3rd	5th		Sag	3rd	5th	
250	18	3.70	6.17		19	3.80	6.34		20	3.85	6.42		21	3.95	6.58		22	4.04	6.74		23	4.14	6.89	
255	19	3.77	6.29		20	3.88	6.46		21	3.93	6.55		22	4.03	6.71		23	4.12	6.87		24	4.22	7.03	
260	20	3.85	6.41		21	3.95	6.59		22	4.01	6.68		23	4.11	6.84		24	4.21	7.01		25	4.30	7.17	
265	21	3.92	6.54		22	4.03	6.72		22	4.08	6.80		24	4.19	6.98		25	4.29	7.14		26	4.38	7.31	
270	21	4.00	6.66		23	4.11	6.84		23	4.16	6.93		24	4.26	7.11		26	4.37	7.28		27	4.47	7.45	
275	22	4.07	6.78		23	4.18	6.97		24	4.24	7.06		25	4.34	7.24		27	4.45	7.41		28	4.55	7.58	
280	23	4.14	6.91		24	4.26	7.10		25	4.31	7.19		26	4.42	7.37		28	4.53	7.55		29	4.63	7.72	
285	24	4.22	7.03		25	4.33	7.22		26	4.39	7.32		27	4.50	7.50		29	4.61	7.68		30	4.72	7.86	
290	25	4.29	7.15		26	4.41	7.35		27	4.47	7.45		28	4.58	7.63		30	4.69	7.82		31	4.80	8.00	
295	26	4.37	7.28		27	4.49	7.48		28	4.54	7.57		29	4.66	7.77		31	4.77	7.95		32	4.88	8.14	
300	26	4.44	7.40		28	4.56	7.60		29	4.62	7.70		30	4.74	7.90		32	4.85	8.09		33	4.96	8.27	
305	27	4.51	7.52		29	4.64	7.73		30	4.70	7.83		31	4.82	8.03		33	4.93	8.22		34	5.05	8.41	
310	28	4.59	7.65		30	4.71	7.86		31	4.78	7.96		32	4.90	8.16		34	5.01	8.36		35	5.13	8.55	
315	29	4.66	7.77		31	4.79	7.98		32	4.85	8.09		33	4.98	8.29		35	5.10	8.49		36	5.21	8.69	
320	30	4.74	7.89		32	4.87	8.11		33	4.93	8.22		34	5.05	8.42		36	5.18	8.63		38	5.29	8.82	
325	31	4.81	8.02		33	4.94	8.24		34	5.01	8.34		35	5.13	8.56		37	5.26	8.76		39	5.38	8.96	
330	32	4.88	8.14		34	5.02	8.36		35	5.08	8.47		36	5.21	8.69		38	5.34	8.90		40	5.46	9.10	
335	33	4.96	8.26		35	5.09	8.49		36	5.16	8.60		38	5.29	8.82		39	5.42	9.03		41	5.54	9.24	
340	34	5.03	8.39		36	5.17	8.62		37	5.24	8.73		39	5.37	8.95		41	5.50	9.17		42	5.63	9.38	
345	35	5.11	8.51		37	5.25	8.74		38	5.31	8.86		40	5.45	9.08		42	5.58	9.30		44	5.71	9.51	
350	36	5.18	8.63		38	5.32	8.87		39	5.39	8.99		41	5.53	9.21		43	5.66	9.44		45	5.79	9.65	
355	37	5.25	8.76		39	5.40	9.00		40	5.47	9.11		42	5.61	9.34		44	5.74	9.57		46	5.87	9.79	
360	38	5.33	8.88		40	5.47	9.12		41	5.55	9.24		43	5.69	9.48		45	5.82	9.70		48	5.96	9.93	
365	39	5.40	9.00		41	5.55	9.25		42	5.62	9.37		45	5.76	9.61		47	5.90	9.84		49	6.04	10.07	
370	40	5.48	9.13		42	5.63	9.38		44	5.70	9.50		46	5.84	9.74		48	5.98	9.97		50	6.12	10.20	
375	41	5.55	9.25		44	5.70	9.50		45	5.78	9.63		47	5.92	9.87		49	6.07	10.11		52	6.21	10.34	
380	42	5.62	9.37		45	5.78	9.63		46	5.85	9.76		48	6.00	10.00		51	6.15	10.24		53	6.29	10.48	
385	44	5.70	9.50		46	5.85	9.76		47	5.93	9.88		50	6.08	10.13		52	6.23	10.38		54	6.37	10.62	
390	45	5.77	9.62		47	5.93	9.88		48	6.01	10.01		51	6.16	10.27		53	6.31	10.51		56	6.45	10.76	
395	46	5.85	9.74		48	6.01	10.01		50	6.08	10.14		52	6.24	10.40		55	6.39	10.65		57	6.54	10.89	
400	47	5.92	9.87		50	6.08	10.14		51	6.16	10.27		54	6.32	10.53		56	6.47	10.78		59	6.62	11.03	
405	48	5.99	9.99		51	6.16	10.26		52	6.24	10.40		55	6.40	10.66		58	6.55	10.92		60	6.70	11.17	
410	49	6.07	10.11		52	6.23	10.39		54	6.32	10.53		56	6.48	10.79		59	6.63	11.05		62	6.78	11.31	
415	51	6.14	10.24		53	6.31	10.52		55	6.39	10.65		58	6.55	10.92		60	6.71	11.19		63	6.87	11.44	
420	52	6.22	10.36		55	6.39	10.64		56	6.47	10.78		59	6.63	11.06		62	6.79	11.32		65	6.95	11.58	
425	53	6.29	10.48		56	6.46	10.77		58	6.55	10.91		60	6.71	11.19		63	6.87	11.46		66	7.03	11.72	
430	54	6.36	10.61		57	6.54	10.90		59	6.62	11.04		62	6.79	11.32		65	6.96	11.59		68	7.12	11.86	
435	56	6.44	10.73		59	6.61	11.02		60	6.70	11.17		63	6.87	11.45		66	7.04	11.73		70	7.20	12.00	
440	57	6.51	10.85		60	6.69	11.15		62	6.78	11.30		65	6.95	11.58		68	7.12	11.86		71	7.28	12.13	
445	58	6.59	10.98		61	6.77	11.28		63	6.85	11.42		66	7.03	11.71		70	7.20	12.00		73	7.36	12.27	
450	60	6.66	11.10		63	6.84	11.40		64	6.93	11.55		68	7.11	11.85		71	7.28	12.13		74	7.45	12.41	

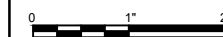


			PROJECT MANAGER	B. HANSON
			DESIGNED BY	
			DRAWN BY	
			CHECKED BY	
2	7-18	BROUGHT UP TO DATE		
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ISSUE	DATE	DESCRIPTION	PROJECT NUMBER	SOM-004

MONTANA STATE UNIVERSITY

BOZEMAN, MONTANA

STRINGING CHARTS



FILENAME	SC1.dwg
SCALE	NONE

SHEET

IV-22

Montana State University																								
Stringing Table																								
Conductor	#4 Swanate										Ruling Span:		350 Feet											
Prepared By: HDR Engineering, Inc.										NESC Medium Loading														
Stringing Chart:		Initial Sags - Sag in inches, span in feet, degrees in Fahrenheit, return of wave in seconds																						
	50 Degrees				55 Degrees				60 Degrees				65 Degrees				70 Degrees				75 Degrees			
	Wave Return				Wave Return				Wave Return				Wave Return				Wave Return				Wave Return			
Span	Sag	3rd	5th		Sag	3rd	5th		Sag	3rd	5th		Sag	3rd	5th		Sag	3rd	5th		Sag	3rd	5th	
250	23	4.18	6.97		24	4.27	7.12		26	4.36	7.27		27	4.45	7.41		28	4.53	7.55		29	4.61	7.69	
255	24	4.27	7.11		25	4.36	7.26		27	4.45	7.41		28	4.54	7.56		29	4.62	7.70		30	4.71	7.84	
260	25	4.35	7.25		26	4.44	7.41		28	4.53	7.56		29	4.62	7.71		30	4.71	7.85		31	4.80	8.00	
265	26	4.43	7.39		28	4.53	7.55		29	4.62	7.70		30	4.71	7.86		31	4.80	8.01		32	4.89	8.15	
270	27	4.52	7.53		29	4.61	7.69		30	4.71	7.85		31	4.80	8.00		32	4.89	8.16		33	4.98	8.31	
275	28	4.60	7.67		30	4.70	7.83		31	4.80	7.99		32	4.89	8.15		33	4.98	8.31		35	5.08	8.46	
280	29	4.68	7.81		31	4.79	7.98		32	4.88	8.14		33	4.98	8.30		35	5.08	8.46		36	5.17	8.61	
285	31	4.77	7.95		32	4.87	8.12		33	4.97	8.28		34	5.07	8.45		36	5.17	8.61		37	5.26	8.77	
290	32	4.85	8.09		33	4.96	8.26		34	5.06	8.43		36	5.16	8.60		37	5.26	8.76		38	5.35	8.92	
295	33	4.94	8.23		34	5.04	8.40		36	5.15	8.58		37	5.25	8.75		38	5.35	8.91		40	5.45	9.08	
300	34	5.02	8.36		35	5.13	8.54		37	5.23	8.72		38	5.34	8.89		40	5.44	9.06		41	5.54	9.23	
305	35	5.10	8.50		36	5.21	8.69		38	5.32	8.87		39	5.43	9.04		41	5.53	9.21		43	5.63	9.38	
310	36	5.19	8.64		38	5.30	8.83		39	5.41	9.01		41	5.51	9.19		42	5.62	9.37		44	5.72	9.54	
315	37	5.27	8.78		39	5.38	8.97		41	5.49	9.16		42	5.60	9.34		44	5.71	9.52		45	5.81	9.69	
320	38	5.35	8.92		40	5.47	9.11		42	5.58	9.30		43	5.69	9.49		45	5.80	9.67		47	5.91	9.84	
325	40	5.44	9.06		41	5.55	9.26		43	5.67	9.45		45	5.78	9.63		47	5.89	9.82		48	6.00	10.00	
330	41	5.52	9.20		43	5.64	9.40		44	5.76	9.59		46	5.87	9.78		48	5.98	9.97		50	6.09	10.15	
335	42	5.60	9.34		44	5.72	9.54		46	5.84	9.74		48	5.96	9.93		49	6.07	10.12		51	6.18	10.31	
340	43	5.69	9.48		45	5.81	9.68		47	5.93	9.88		49	6.05	10.08		51	6.16	10.27		53	6.28	10.46	
345	45	5.77	9.62		47	5.90	9.83		49	6.02	10.03		51	6.14	10.23		52	6.25	10.42		54	6.37	10.61	
350	46	5.86	9.76		48	5.98	9.97		50	6.10	10.17		52	6.23	10.38		54	6.34	10.57		56	6.46	10.77	
355	47	5.94	9.90		49	6.07	10.11		51	6.19	10.32		53	6.31	10.52		56	6.43	10.72		58	6.55	10.92	
360	49	6.02	10.04		51	6.15	10.25		53	6.28	10.47		55	6.40	10.67		57	6.53	10.88		59	6.65	11.08	
365	50	6.11	10.18		52	6.24	10.40		54	6.37	10.61		57	6.49	10.82		59	6.62	11.03		61	6.74	11.23	
370	51	6.19	10.32		54	6.32	10.54		56	6.45	10.76		58	6.58	10.97		60	6.71	11.18		63	6.83	11.38	
375	53	6.27	10.46		55	6.41	10.68		57	6.54	10.90		60	6.67	11.12		62	6.80	11.33		64	6.92	11.54	
380	54	6.36	10.60		57	6.49	10.82		59	6.63	11.05		61	6.76	11.27		64	6.89	11.48		66	7.01	11.69	
385	56	6.44	10.73		58	6.58	10.97		61	6.72	11.19		63	6.85	11.41		65	6.98	11.63		68	7.11	11.84	
390	57	6.52	10.87		60	6.66	11.11		62	6.80	11.34		65	6.94	11.56		67	7.07	11.78		70	7.20	12.00	
395	59	6.61	11.01		61	6.75	11.25		64	6.89	11.48		66	7.03	11.71		69	7.16	11.93		71	7.29	12.15	
400	60	6.69	11.15		63	6.84	11.39		65	6.98	11.63		68	7.11	11.86		71	7.25	12.08		73	7.38	12.31	
405	62	6.78	11.29		64	6.92	11.54		67	7.06	11.77		70	7.20	12.01		72	7.34	12.24		75	7.48	12.46	
410	63	6.86	11.43		66	7.01	11.68		69	7.15	11.92		71	7.29	12.15		74	7.43	12.39		77	7.57	12.61	
415	65	6.94	11.57		67	7.09	11.82		70	7.24	12.06		73	7.38	12.30		76	7.52	12.54		79	7.66	12.77	
420	66	7.03	11.71		69	7.18	11.96		72	7.33	12.21		75	7.47	12.45		78	7.61	12.69		81	7.75	12.92	
425	68	7.11	11.85		71	7.26	12.11		74	7.41	12.35		77	7.56	12.60		80	7.70	12.84		83	7.84	13.07	
430	69	7.19	11.99		72	7.35	12.25		75	7.50	12.50		78	7.65	12.75		82	7.79	12.99		85	7.94	13.23	
435	71	7.28	12.13		74	7.43	12.39		77	7.59	12.65		80	7.74	12.90		83	7.88	13.14		87	8.03	13.38	
440	73	7.36	12.27		76	7.52	12.53		79	7.67	12.79		82	7.83	13.04		85	7.98	13.29		89	8.12	13.54	
445	74	7.44	12.41		78	7.60	12.67		81	7.76	12.94		84	7.92	13.19		87	8.07	13.44		91	8.21	13.69	
450	76	7.53	12.55		79	7.69	12.82		83	7.85	13.08		86	8.00	13.34		89	8.16	13.59		93	8.31	13.84	

Montana State University																		
Stringing Table																		
Conductor	#4 Swanate										Ruling Span:		350 Feet					
Prepared By: HDR Engineering, Inc.										NESC Medium Loading								
Stringing Chart: Initial Sags - Sag in inches, span in feet, degrees in Fahrenheit, return of wave in seconds																		
	80 Degrees			85 Degrees			90 Degrees			95 Degrees			100 Degrees			105 Degrees		
	Wave Return			Wave Return			Wave Return			Wave Return			Wave Return			Wave Return		
Span	Sag	3rd	5th	Sag	3rd	5th	Sag	3rd	5th	Sag	3rd	5th	Sag	3rd	5th	Sag	3rd	5th
250	30	4.70	7.83	31	4.78	7.96	32	4.86	8.09	33	4.93	8.22	34	5.01	8.35	35	5.09	8.48
255	31	4.79	7.98	32	4.87	8.12	33	4.95	8.25	34	5.03	8.39	35	5.11	8.52	36	5.19	8.64
260	32	4.88	8.14	33	4.97	8.28	34	5.05	8.42	35	5.13	8.55	36	5.21	8.68	38	5.29	8.81
265	33	4.98	8.30	34	5.06	8.44	36	5.15	8.58	37	5.23	8.72	38	5.31	8.85	39	5.39	8.98
270	35	5.07	8.45	36	5.16	8.60	37	5.24	8.74	38	5.33	8.88	39	5.41	9.02	40	5.49	9.15
275	36	5.17	8.61	37	5.25	8.76	38	5.34	8.90	40	5.43	9.04	41	5.51	9.18	42	5.59	9.32
280	37	5.26	8.77	38	5.35	8.92	40	5.44	9.06	41	5.53	9.21	42	5.61	9.35	44	5.70	9.49
285	38	5.35	8.92	40	5.45	9.08	41	5.54	9.23	42	5.62	9.37	44	5.71	9.52	45	5.80	9.66
290	40	5.45	9.08	41	5.54	9.23	43	5.63	9.39	44	5.72	9.54	45	5.81	9.69	47	5.90	9.83
295	41	5.54	9.24	43	5.64	9.39	44	5.73	9.55	45	5.82	9.70	47	5.91	9.85	48	6.00	10.00
300	43	5.64	9.39	44	5.73	9.55	46	5.83	9.71	47	5.92	9.87	48	6.01	10.02	50	6.10	10.17
305	44	5.73	9.55	46	5.83	9.71	47	5.92	9.87	49	6.02	10.03	50	6.11	10.19	52	6.20	10.34
310	46	5.82	9.71	47	5.92	9.87	49	6.02	10.03	50	6.12	10.20	52	6.21	10.35	53	6.31	10.51
315	47	5.92	9.86	49	6.02	10.03	50	6.12	10.20	52	6.22	10.36	53	6.31	10.52	55	6.41	10.68
320	48	6.01	10.02	50	6.11	10.19	52	6.22	10.36	53	6.31	10.52	55	6.41	10.69	57	6.51	10.85
325	50	6.11	10.18	52	6.21	10.35	53	6.31	10.52	55	6.41	10.69	57	6.51	10.85	59	6.61	11.02
330	52	6.20	10.33	53	6.31	10.51	55	6.41	10.68	57	6.51	10.85	59	6.61	11.02	60	6.71	11.19
335	53	6.29	10.49	55	6.40	10.67	57	6.51	10.84	59	6.61	11.02	60	6.71	11.19	62	6.81	11.36
340	55	6.39	10.65	57	6.50	10.83	59	6.60	11.01	60	6.71	11.18	62	6.81	11.36	64	6.92	11.53
345	56	6.48	10.80	58	6.59	10.99	60	6.70	11.17	62	6.81	11.35	64	6.91	11.52	66	7.02	11.70
350	58	6.57	10.96	60	6.69	11.15	62	6.80	11.33	64	6.91	11.51	66	7.01	11.69	68	7.12	11.87
355	60	6.67	11.11	62	6.78	11.30	64	6.89	11.49	66	7.01	11.68	68	7.11	11.86	70	7.22	12.03
360	61	6.76	11.27	63	6.88	11.46	66	6.99	11.65	68	7.10	11.84	70	7.21	12.02	72	7.32	12.20
365	63	6.86	11.43	65	6.97	11.62	67	7.09	11.82	70	7.20	12.00	72	7.31	12.19	74	7.42	12.37
370	65	6.95	11.58	67	7.07	11.78	69	7.19	11.98	72	7.30	12.17	74	7.41	12.36	76	7.53	12.54
375	67	7.04	11.74	69	7.17	11.94	71	7.28	12.14	73	7.40	12.33	76	7.51	12.52	78	7.63	12.71
380	68	7.14	11.90	71	7.26	12.10	73	7.38	12.30	75	7.50	12.50	78	7.61	12.69	80	7.73	12.88
385	70	7.23	12.05	73	7.36	12.26	75	7.48	12.46	77	7.60	12.66	80	7.72	12.86	82	7.83	13.05
390	72	7.33	12.21	74	7.45	12.42	77	7.57	12.62	79	7.70	12.83	82	7.82	13.03	84	7.93	13.22
395	74	7.42	12.37	76	7.55	12.58	79	7.67	12.79	82	7.79	12.99	84	7.92	13.19	87	8.03	13.39
400	76	7.51	12.52	78	7.64	12.74	81	7.77	12.95	84	7.89	13.16	86	8.02	13.36	89	8.14	13.56
405	78	7.61	12.68	80	7.74	12.90	83	7.87	13.11	86	7.99	13.32	88	8.12	13.53	91	8.24	13.73
410	80	7.70	12.84	82	7.83	13.06	85	7.96	13.27	88	8.09	13.48	91	8.22	13.69	93	8.34	13.90
415	82	7.80	12.99	84	7.93	13.22	87	8.06	13.43	90	8.19	13.65	93	8.32	13.86	96	8.44	14.07
420	84	7.89	13.15	86	8.02	13.37	89	8.16	13.60	92	8.29	13.81	95	8.42	14.03	98	8.54	14.24
425	86	7.98	13.31	88	8.12	13.53	91	8.25	13.76	94	8.39	13.98	97	8.52	14.19	100	8.64	14.41
430	88	8.08	13.46	91	8.22	13.69	94	8.35	13.92	97	8.49	14.14	100	8.62	14.36	103	8.75	14.58
435	90	8.17	13.62	93	8.31	13.85	96	8.45	14.08	99	8.58	14.31	102	8.72	14.53	105	8.85	14.75
440	92	8.27	13.78	95	8.41	14.01	98	8.55	14.24	101	8.68	14.47	104	8.82	14.70	107	8.95	14.92
445	94	8.36	13.93	97	8.50	14.17	100	8.64	14.41	103	8.78	14.64	107	8.92	14.86	110	9.05	15.09
450	96	8.45	14.09	99	8.60	14.33	102	8.74	14.57	106	8.88	14.80	109	9.02	15.03	112	9.15	15.26



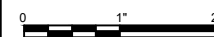
2	7-18	BROUGHT UP TO DATE
1	4-07	BROUGHT UP TO DATE
ISSUE	DATE	DESCRIPTION

PROJECT MANAGER		B. HANSON
DESIGNED BY		
DRAWN BY		
CHECKED BY		
PROJECT NUMBER	SOM-004	

MONTANA STATE UNIVERSITY

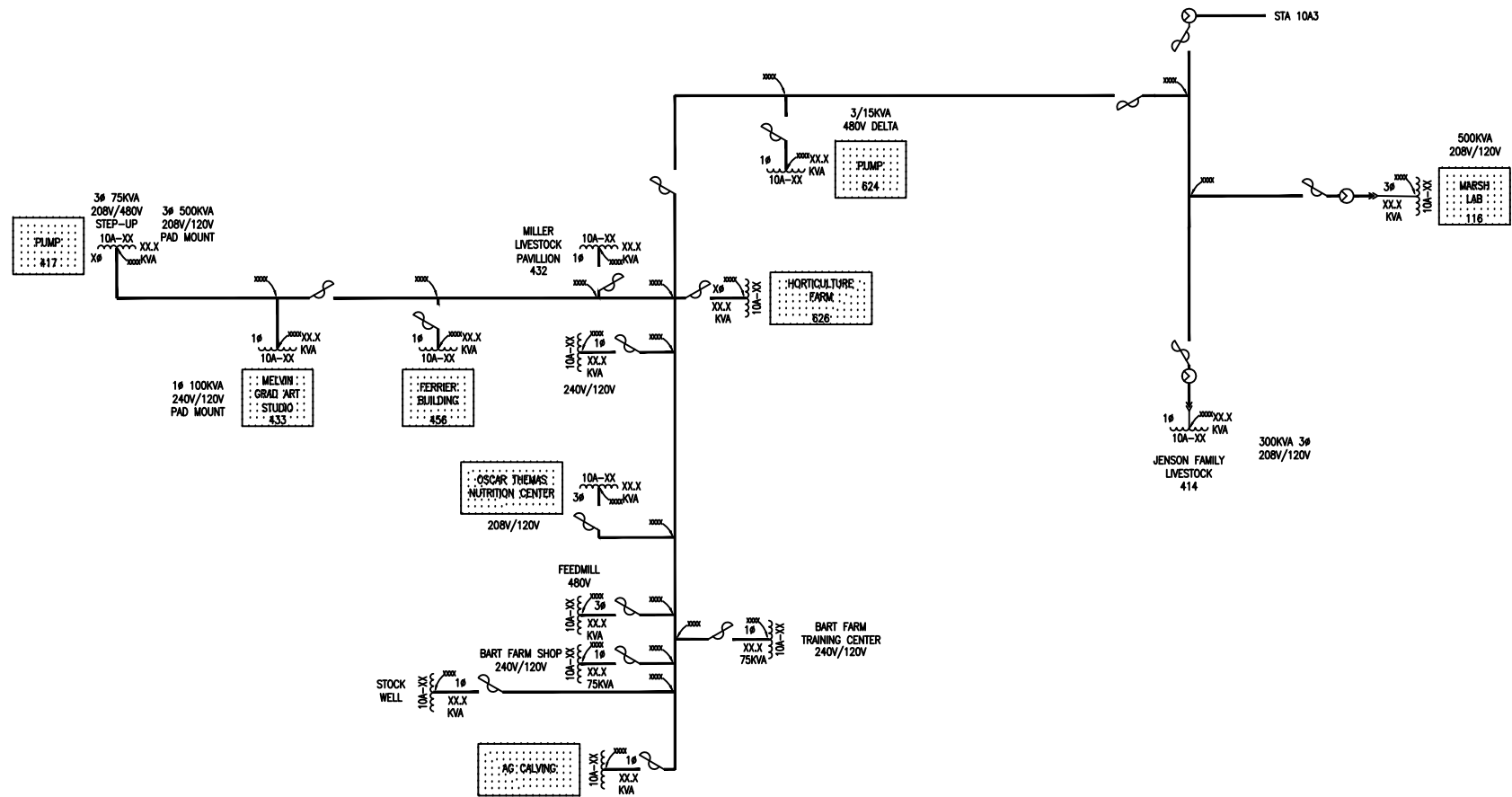
BOZEMAN, MONTANA

ONE LINE OPERATING DIAGRAM NEW SYSTEM



FILENAME	SOMOL02D1.dwg
SCALE	NONE

SHEET
IV-2



LEGEND

PAD MOUNT SWITCHGEAR, STATION NO. NOTED.*
FUSE SIZE NOTED, 2-INDICATES 200 AMP
6-INDICATES 600 AMP SWITCH.

PAD MOUNT TRANSFORMER WITH INTERNAL SWITCH.
NUMBER OF PHASES NOTED, STATION NO. NOTED.*
KVA SIZE AND VOLTAGE CODE NOTED.
-1 INDICATES 208V/120 VOLTS.
-3 INDICATES 480V/277 VOLTS.

PAD MOUNT, JUNCTION ENCLOSURE.
STATION NO. NOTED.*

PAD MOUNT PRIMARY METERING.
STATION NO. NOTED.*

INDICATES ELBOW TYPE CABLE TERMINATIONS.

INDICATES PRIMARY FUSE.

INDICATES FAULT INTERRUPTER.

FAULT INDICATOR, AUTO RESET.

MANHOLE NEW, STATION NO. NOTED.

MANHOLE EXISTING, STATION NO. NOTED.

DESIGNATES MANHOLE.
STATION NO. NOTED.

FACILITY SERVED, NAME AND
NUMBER NOTED.

EXISTING 15KV DISTRIBUTION CIRCUITS
UNDERGROUND UNLESS NOTED OTHERWISE.

NEW 15KV UNDERGROUND
DISTRIBUTION CIRCUITS.

OVERHEAD FUSE CUTOUT

*FOR LOCATIONS WHERE TWO STATION NUMBERS ARE
SHOWN I.E. 9A-1(9C-1), CONTRACTOR SHALL RESTENCIL
EQUIPMENT CABINET AND RELABEL CABLE TERMINALS WITH
NEW STATION NUMBER SHOWN IN PARENTHESIS. REFER
TO WRITTEN SPECIFICATION FOR LABELING REQUIREMENTS.



2	7-18	BROUGHT UP TO DATE
1	4-07	BROUGHT UP TO DATE
ISSUE	DATE	DESCRIPTION

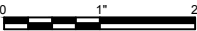
PROJECT MANAGER B. HANSON

DESIGNED BY	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	SOM-004

MONTANA STATE UNIVERSITY

BOZEMAN, MONTANA

ONE LINE OPERATING DIAGRAM
NEW SYSTEM



FILENAME | SOMOL03D1.dwg
SCALE | NONE

SHEET
IV-25